# Appendix G-5

# Operating Guidelines to Manage Impacts on Fisheries from Reservoir Level Fluctuations

# OPERATING GUIDELINES TO MANAGE IMPACTS ON RESERVOIR FISHERIES FROM RESERVOIR LEVEL FLUCTUATIONS

## Executive Summary

As a result of negotiations between the Brazos River Authority (BRA) and the Texas Parks and Wildlife Department (TPWD), Special Conditions Section D. "Water Management Plan Special Conditions" within the proposed System Operation Permit contains the following:

> "4) The issues addressed in the initial application for approval of the WMP shall include, but not be limited to the following:
>
> > e. Development of operating guidelines to manage the frequency and magnitude of reservoir level fluctuations to avoid or minimize impacts on fisheries. The operating guidelines may be subject to temporary suspension if necessary for water supply purposes."

As a result, BRA examined the effects that changes in lake levels and duration of lake level drawdown might have on BRA Water Supply System (System) reservoir fisheries and associated littoral habitat. The fisheries in all 11 System reservoirs are managed by TPWD. The term "fisheries," as it applies to fisheries management, includes not only the fish and aquatic species populations that inhabit a body of water but also the habitat and recreational use of the resources. Review of recent TPWD fisheries reports by reservoir indicates that despite historic variation in reservoir elevations, the BRA System reservoirs support a fishery that is resilient to the effects of the drought-flood cycle in Texas.

The BRA, with the assistance of TPWD's Inland Fisheries Division, quantified littoral habitat in each System reservoir and identified the elevation below which littoral habitat availability and quality is reduced. Historical data from System reservoirs shows that drawdown below these threshold elevations is infrequent and often of short duration (one year or less). The examination reveals that no single, System-wide strategy to support managed reservoir fisheries is adequately protective of littoral habitat needed in all reservoirs; therefore the BRA and TPWD jointly developed reservoir-specific threshold elevations and a general operating guideline designed to provide adequate littoral habitat for maintenance of the reservoir fisheries.

The reservoir-specific thresholds and the general guideline are not intended to be an annual operating plan for the System reservoirs, nor will the reservoirs be intentionally drawn down to threshold elevations. The reservoir-specific thresholds and guideline are intended to provide the BRA direction regarding reservoir usage during times of drought conditions or other occurrences. Drought may cause one or more of the System reservoirs to fall below the threshold elevation for periods of time sufficient to cause impairment to littoral habitat and the associated fisheries. Additionally, these guidelines will provide direction to TPWD fisheries managers in how the BRA can be anticipated to manage reservoirs during times of drought or other causes of low reservoir elevations. They will allow TPWD and the BRA to work collaboratively to minimize or mitigate impacts and help TPWD determine if adjustments to fisheries management strategies are necessary.

## I. Introduction

The BRA System includes 17 water rights, 12 of which are associated with reservoirs. These permits authorize total priority diversions in excess of 700,000 acre-feet per year and a combined impoundment of approximately 2,400,000 acre-feet.

The BRA owns and operates three reservoirs (Possum Kingdom, Granbury, and Limestone) and has partial ownership rights in the permitted Allens Creek Reservoir. The BRA also holds water rights in the conservation pools of eight reservoirs operated by the U.S. Army Corps of Engineers (USACE): Lakes Aquilla, Belton, Georgetown, Granger, Proctor, Somerville, Stillhouse Hollow, and Whitney. Of the USACE reservoirs, the BRA is the sole water right holder in the reservoirs with the exceptions of Lakes Whitney and Belton. BRA holds a contract with the USACE for 22% of the conservation pool capacity between elevations 520 and 533 feet above mean sea level (msl) in Lake Whitney. The remainder of the conservation pool between elevations 520 msl and 533 msl is used for hydroelectric power generation. In addition to the BRA, Fort Hood has water rights in Lake Belton for authorized diversions of 12,000 acre-feet per year.

The BRA supplies raw water to customers throughout the Brazos River basin. Some customers divert water directly from the reservoirs, whereas others are located downstream of a reservoir, or multiple reservoirs, and require water to be released to them. System operation in the context of the existing System Operation Order (System Order) pertains to these releases for customers that are located downstream of more than one reservoir. The System Order, originally approved in 1964, provides for some flexibility in the operation of the System in terms of where releases can be made for supplying downstream customers. However, BRA's existing water rights and the System Order do not allow the BRA to take full advantage of the additional water supply made available through this operational flexibility. The proposed System Operation Permit currently being sought by BRA will allow it to use this additional water supply. The proposed System Operation Permit requires the BRA to address the development of operating guidelines to manage the frequency and magnitude of reservoir level fluctuations to avoid or minimize impacts on reservoir fisheries. This report documents study work conducted to meet this requirement, and outlines the reservoir-specific threshold elevations and general operating guideline resulting from that analysis.

Current operation of the System complies with the System Order, provides a safeguard of local water supply needs, and requires the BRA to exclude a reservoir from System

Operations during any period of time in which the BRA's permitted storage in that reservoir is less than 30% (30% Rule). In such event, no releases shall be made from such reservoir except for local needs so long as any other System reservoir which can meet System needs remains at more than 30% of its permitted storage. While this requirement may provide some protection of local fisheries, habitat, prolonged occurrence of lake elevations at or below 30% of capacity would result in reduced fishery size.

The Texas Water Development Board (TWDB) publishes population and water demand projections for each county in the state. By 2060, the population in parts of the state is anticipated to double, with three of the fastest growing areas located in the Brazos River basin (TWDB 2010 and 2010a). With this anticipated increase in population comes an anticipated increase in water demand to service municipal, manufacturing and steam-electric needs. Without construction and/or development of new surface water and groundwater supplies to meet the growing demands for water, it is probable that it may be more difficult to meet water demands and maintain reservoir water levels throughout the state. Water level fluctuations regardless of cause may negatively affect littoral habitat availability and quality and thus affect the fisheries dependent on the littoral zones of reservoirs, depending on the severity and duration of drawdown.

The following sections of this Report summarize pertinent scientific literature regarding reservoir levels and fisheries habitat, outline the various methods utilized by the BRA and TPWD in this study, summarize the results obtained through those various methods, and outline the reservoir-specific threshold elevations and general operating guideline resulting from this work,

## II. Literature Review

Each fish species has particular needs for shelter and food which can change throughout the species' life cycle. While different species may utilize the pelagic and/or benthic zones of a reservoir for specific purposes, the littoral zone of a reservoir (area close to the shore) supports some stage of the life cycle for almost every species of fish. Two of the most important life functions for maintaining a reservoir fishery are spawning and recruitment. Most fish spawning activity takes place in the littoral areas of reservoirs (Walburg 1977). The littoral zone of a reservoir generally provides the variety of habitat needed to support a wide variety of species by providing fine (e.g., sand, silt, clay, and detritus) and coarse (e.g., gravel, cobble, and boulder), as well as structural habitat such as coarse woody debris and aquatic vegetation. These components are needed by a variety of species for spawning and to provide protective cover for young fish.

While reservoir construction has increased the overall amount of aquatic habitat in the Brazos River basin, the reservoirs are artificial aquatic systems that are somewhat unpredictable, in regards to habitat availability and water levels, due to their dynamic nature, young age (<100 years) and lack of thorough historical record. Additionally, there is contradictory research regarding what factors affect year-class strength, population abundance, size structure, and ultimately fishery quality, which makes determining a single strategy to optimize all aspects of fisheries maintenance difficult.

Year-class strength (i.e., the relative number of offspring produced each year) has been the focus of many studies. Year-class strength is dependent on life history (e.g. longevity, mortality, growth) and fishery characteristics (e.g. exploitation rates). Short-lived, highly exploited species may benefit from more frequent strong year classes, while long-lived species may provide quality fisheries with less frequent strong year classes (Daugherty and Smith, in press). Recent TPWD research revealed that moderate frequencies of strong year classes reduced harvest but improved population size structure for fish of both short and intermediate longevity. However, moderate frequencies of strong year classes for long-lived fish improved both harvest and size structure (Daugherty and Smith, in press).

Several studies have identified a direct relationship between year-class strength and reservoir water level (Aggus and Elliot 1975; Timmons et al. 1980; Martin et al. 1981; Miranda et al. 1984; Meals and Miranda 1991). Greater reproductive success has been documented during springs with high water levels. This can be attributed to access to flooded shoreline vegetation which provides suitable spawning substrate and protective cover for offspring.

However, year-class strength and recruitment responses related to hydrology vary by species. TPWD has identified strong year-class responses to hydrologic factors in largemouth bass, blue catfish and white crappie, but has identified no response related to hydrology for channel catfish (Smith et al. 2009). Additionally, their research indicates that some hydrologic variability is normal and can have a minimal impact on fisheries quality. They have also postulated that consistently strong annual recruitment may not be necessary to maintain fisheries. TPWD's research does suggest that fishery quality may be affected if hydrology becomes variable enough to result in consecutive, missing or very weak year classes (Daugherty and Smith, in press).

Martin et al. (1981) found that while reproductive success for some species is greatest when spring water levels are high, the high-water levels appear to have little impact on first-summer growth rates. Many other studies have concluded that consistently strong year classes result in greater abundance but reduced growth for some species (Gabelhouse 1984; Buynak and Michell 2002). Whether abundance or size is most important depends on fisheries management goals for each individual reservoir.

Additionally, the availability of suitable habitats for early life history stages is crucial to successful recruitment (Walters and Juanes 1993). Many studies establish a strong link between the availability of coarse substrate and reproductive success, predation avoidance and recruitment of different fish species (Irwin 1994; Annett et al. 1996; Irwin et al. 1997). For some species, woody and/or vegetative cover plays an equally important role in recruitment (Martin et al. 1981; Strange et al. 1982; Savion and Stein 1982; Schlechte and Buckmeier 2006). The suitability of these habitat types suggests that in years when water levels fall below the reservoir-specific thresholds, year-class strength may be reduced and long-term (5 years or more) water level reductions below the thresholds may result in significant degradation of fisheries quality.

Given that both abundance and size structure contribute to fishery quality, Martin et al. (1981) recommended a reservoir management strategy to improve fisheries that consists of a rotating schedule of purposeful, multi-year lake level drawdowns. The purpose of this approach would be to encourage vegetative growth followed by a year where spring lake levels are maintained at the top of the conservation pool, thus inundating the new vegetative growth. Several other studies also recommend an intermediate frequency of strong year classes as a management measure to balance abundance and size structure (Anderson and Neumann 1996; Keith 1975; Daugherty and Smith, in press).

Ploskey (1993) conducted a study to evaluate several operating plan options for the Upper Missouri River basin and its six reservoirs that would provide for the equitable use of resources for authorized purposes (hydropower, flood control, water supply, navigation, water quality, recreation, and fish and wildlife). He used correlation and regression analysis to quantify the effects of seasonal or annual variations in reservoir hydrology on young-of-year fish in summer. Through the analysis of historical data, the author determined that the densities of young-of-year fish are highest in years with high-water levels in the spring, supporting the idea that water levels during the spring spawning season are a factor in maintaining a robust fishery.

Computer models were then used to evaluate four operational strategies. Options that limited annual drawdown were determined desirable only for periods of severe drought. One option evaluated was very similar to the recommendation made by Martin et al. (1981), artificially providing a year of high-water to one of the three largest reservoirs in the system on a rotating basis (i.e., high-water insured every third year). This option was determined by the USACE to potentially yield the greatest benefit to natural fish reproduction. Additionally, Keith (1975) also recommended water-level increases every three to five years to produce strong largemouth bass cohorts. Daugherty and Smith (in press) concluded that intermediate frequencies of strong year classes provided the greatest benefit to fisheries when a balance of harvest and size structure is desired, and that management plans promoting strong year classes at fixed intervals would aid in reducing fisheries variability. However, this should not be interpreted to mean no reproduction is occurring or needed in the interim years, and it should be noted that it is not advisable to have only one year class every three to five years. Natural reproduction and recruitment, even if at lower levels during the interim years, are also needed to sustain a fishery.

However, it must be noted that implementation of such a recommended reservoir manipulation strategy is more practical in the Missouri River basin because there is a more reliable supply of inflows to refill reservoirs intentionally drawn down. In Texas, artificially drawing down reservoirs for multi-year periods is impractical. The ability to refill the reservoir at the appropriate time to benefit fisheries is highly impacted by timing of precipitation events and resulting streamflow. Additionally, such drawdowns could have a negative impact on water supply, navigation, and accessibility to recreational structures (e.g. boat ramps and marina docks). Given the flashy nature of the Brazos River basin, artificially elevating lake levels could:

- potentially interfere with the System's flood risk reduction purposes;
- threaten the structural integrity of the dams;
- increase wave action and make shorelines more susceptible to erosion;
- interfere with fixed recreational structures; and
- lead to a loss of riparian vegetation that provides valuable habitat to wildlife.

A long-term study of the fish assemblage of Lake Texoma assessed the stability of the fish assemblage in response to water level fluctuations, sedimentation, and establishment of introduced, non-native species (Gido et al. 2000). They concluded that, over the 43-year life of the reservoir and in spite of variable lake levels, the fish assemblage in Lake Texoma was in equilibrium and stable. They also concluded that non-native, introduced species in the reservoir were more susceptible to abiotic disturbances than species native to the impounded river basin that have inhabited the lake. The reason postulated for the greater resilience of native species in the lake is that they are already adapted to the highly variable environment found in Texas and Oklahoma (Gido et al. 2000).

All these studies confirm that fluctuating water levels in reservoirs are not necessarily detrimental to fisheries and under the right circumstances may even be beneficial. Constant lake levels are beneficial in aiding the establishment and persistence of aquatic vegetative habitat; however, it must be noted that constant lake levels are not feasible to maintain in Texas due to the drought-flood cycle.

## III. Methods

### *Historic System Reservoir Elevation and Capacity*

Elevation-area-capacity data were obtained from the most recent Texas Water Development Board (TWDB) Volumetric Survey for each System reservoir. Top of conservation (TOC) pool elevations were adopted from the most recent TWDB volumetric surveys, with the exception of Possum Kingdom and Granbury. Full pool elevations for Possum Kingdom and Granbury were adopted from the 2011 Possum Kingdom-Granbury-Whitney Water Management Study (BRA 2011). Historical reservoir capacities and elevations were evaluated against these levels from January 1, 1985 through January 31, 2012 to determine rates of frequency of drawdown and/or, in the case of the USACE reservoirs, flood pool storage. Lakes Aquilla, Georgetown and Granger were not impounded until the early 1980s. Starting data analysis in 1985 allowed time for all System reservoirs to reach total storage capacity and for managed and unmanaged fish populations to become established. Additionally, while capacity and elevation data are available for varying periods on some reservoirs prior to 1985, these prior data were judged to not reflect current storage capacities and TOC elevations, impacts from sedimentation, rates of reservoir water use, and population growth.

### *Impact of Cessation of Hydroelectric Generation at Possum Kingdom Lake on Mainstem Reservoirs*

An analysis of reservoir capacities with and without hydroelectric generation at Possum Kingdom Lake was performed for the three mainstem System reservoirs: Lake Possum Kingdom, Lake Granbury, and Lake Whitney.

***Review of the System Order - 30% Rule***

A review of each reservoir's historical elevation and capacity data was conducted to determine compliance with the System Order's 30% Rule and to determine if compliance with that rule provided any degree of protection of littoral habitat.

***Reservoir-Specific Fisheries Data***

TPWD samples and assesses the status of game fish populations at all major public reservoirs that are greater than 500 acres in size, on a four-year rotational basis. The assessments evaluate the status, utilization and value of freshwater fishery resources in each reservoir in order to develop or adjust management strategies, to assess the effectiveness of previous management strategies, to prevent resource depletion, and to optimize fishery yield. The most current assessments for each System reservoir were reviewed to determine the current status of System reservoir fisheries.

***Data Collection***

TPWD's Inland Fisheries staff quantified surface elevation-specific littoral habitat quality and availability in each of the System reservoirs. High-quality littoral habitat was generally defined as coarse substrate or the presence of structure (e.g. vegetation and coarse woody debris) (Daugherty et al. 2009).

The depth of the littoral zone, the near shore area where sunlight penetrates all the way to the sediment, in each reservoir was determined based on Secchi disk measurements recorded during previous fishery surveys. Using reservoir contour models provided by BRA, estimates of elevation-specific littoral zone area in each reservoir were generated in ArcGIS 9.3 (Environmental Systems Research Institute; Redlands, California). Select-by-attribute routines were used to extract elevation-specific contour lines, which were exported to independent shapefiles and converted to polygon layers depicting reservoir surface area at each water level. Based on Secchi depth estimates of littoral zone depth, the shapefiles detailing reservoir surface area were then used to estimate littoral zone coverage at each reservoir elevation both spatially and numerically, using the erase features tool based on the following formula:

$$LZ = R_x - R_{(x-y)}$$

Where *LZ* is the estimated littoral zone coverage, $R_x$ is the surface area of the reservoir at *x* elevation, and *y* is Secchi depth. The area (in hectares) of the resulting data layers were then calculated.

Littoral-zone habitat quality data for all System reservoirs was collected by TPWD fisheries biologists in May and June 2012. Characterization of littoral habitat was accomplished using a stratified random sampling design. Each System reservoir was divided into upper, middle and lower reaches along the longitudinal axis of the reservoir using ArcGIS. Twenty-five random sampling points along the reservoir shoreline were identified within each reach for habitat characterization. Thus, a total of 75 sampling points were used in each reservoir.

At each sampling location, side-scan sonar was used to collect geo-referenced data on substrate and structural habitat characteristics within the littoral zone. A 50-meter scan parallel to the reservoir shoreline was used to record habitat characteristics along the shoreline, followed by a second transect run perpendicular to the reservoir shoreline either 200 m in length or to the water depth associated with 30% reservoir capacity, whichever occurred first.

Side-scan images at each sampling location were then interpreted using ArcGIS software. Substrates were classified as either fine (sand, silt, clay) or coarse (gravel, cobble, boulder or bedrock) as defined by Wentworth (1922) and Cummins (1962). Aquatic vegetation, as well as standing and downed timber, were also interpreted and recorded for each image. Substrate and aquatic vegetation coverages were delineated as polygon shapefiles in the ArcGIS document, whereas downed timber and standing timber were delineated as polyline and point layers, respectively.

To assess littoral habitat quality, data layers characterizing elevation-specific littoral zone areas were overlain on the habitat quality data layers characterizing substrate and structural habitat in an ArcMAP document. For each elevation-specific littoral zone, the associated littoral habitat was isolated using the clip features tool (for substrate and aquatic vegetation polygon layers) and select by location routines (for downed timber polylines and standing timber point data layers) to quantitatively describe the littoral habitat quality within each elevation-specific littoral zone.

To assess recreational access, TPWD Inland Fisheries staff used side-scan sonar to identify the terminus of each public boat ramp on each System reservoir. The location of the terminus was then plotted against the contour data for each respective reservoir to determine the elevation at which each boat access location was unusable (i.e., no longer inundated). For Possum Kingdom, Granbury and Limestone, the elevations at which recreation access is impeded is the elevation at which BRA Lake Operations staff has determined public access facilities to be unsafe (generally one to three feet above launch terminus). To ensure comparability and better account for when launch use becomes impeded, two feet were added to each of TPWD's determination of launch terminus.

***Threshold Determinations***

Littoral habitat results were used to determine surface elevations at which high-quality littoral habitat is reduced or lost in each of the System reservoirs. A review of reservoir-specific fisheries and species-specific components comprising high-quality littoral habitat revealed that a one-size-fits-all approach to reservoir operations will not suffice to adequately protect littoral habitat in all System reservoirs, because species of importance vary by reservoir and each species possesses unique habitat needs. Therefore, threshold elevations vary by reservoir, and represent a level where littoral habitat is reduced but will still support necessary life history functions to support a fishery.

The threshold level for each reservoir was determined by a team of TPWD and BRA biologists. Threshold elevations for the provision of high-quality habitat were selected from points of inflection in the slope of the relationships between high-quality habitat availability and water level. When inflection points varied among regions of a reservoir, a composite point was estimated as the midpoint of the reach's inflection points. Elevations above the inflection point represent greater proportions of high-quality habitat, whereas elevations below the point of inflection signify reduced proportions of high-quality habitat.

Upon review of scientific literature documenting the impacts of fluctuating water levels in lakes and reservoirs on fisheries, TPWD and BRA staff agreed that the maximum duration that a reservoir may be below its designated threshold elevation and still sustain its fishery, is three consecutive years (1,095 days).

***Historical and Predicted Attainment of Thresholds by System Reservoir***

An analysis of historical, daily surface elevations (January 1985 through January 2012) was conducted for each reservoir to determine the historical frequency of occurrence of elevations below the individual threshold for each System reservoir.

Additionally, a Water Availability Model (WAM) was developed to estimate the frequency of occurrence of System reservoir elevations under current demand conditions and based on 2025 projected water demands. The elevation probabilities for each reservoir were compared to the threshold elevation for that particular reservoir to estimate the frequency with which reservoir water levels are predicted to equal or exceed the threshold elevation for each reservoir. The three scenarios developed to compare current and future demand conditions, which correspond to the demand scenario modeling supporting the Water Management Plan, are:

Scenario 1 - Current Conditions

- Uses period of record of TCEQ Brazos WAM
    - January 1940 – December 1997
- Monthly Data
- 2011 Historical BRA Water Demands
- Uses most current reservoir storage information as documented in TWDB Volumetric Surveys for each lake
- Uses current return flow levels as provided by TCEQ

Scenario 2 - 2025 Conditions

- Uses period of record of TCEQ Brazos WAM
    - January 1940 – December 1997
- Monthly Data
- 2025 BRA Water Demands as projected in TWDB 2012 State Water Plan

- Uses projected 2025 reservoir storage based on estimated sedimentation rates for each lake
- Uses return flow volumes permitted under the proposed System Operation Permit
- Includes water use under the proposed System Operation Permit, but does not include Comanche Peak Units 3&4

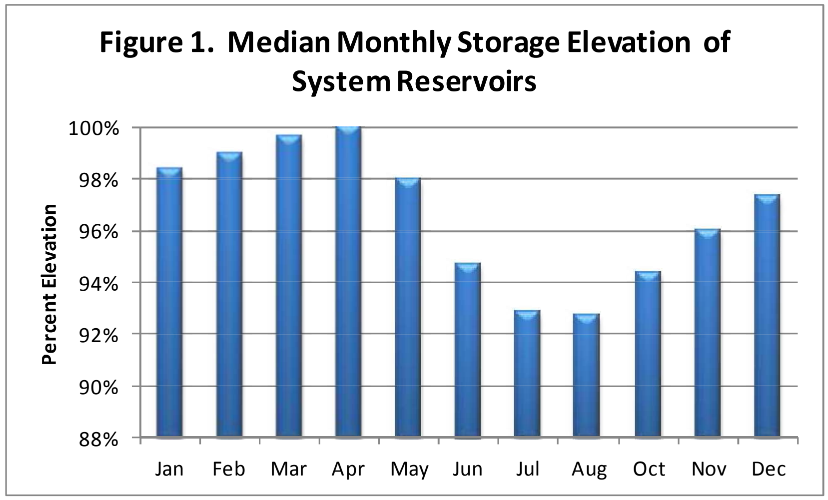
Scenario 3 - 2025 Conditions

- Scenario 2 data plus water use projections for Comanche Peak Units 3&4

## IV. Results

***Historical System Reservoir Elevation***

A review of historical lake level and capacity data in the Brazos River basin indicates the annual median elevation of the System reservoirs is 99.9% of the System's total storage capacity, with the lowest monthly median elevations of 99.7% occurring in July and August (Figure 1; monthly median elevation data by reservoir is included in Appendix A). No significant differences between annual median elevations were identified for any of the System reservoirs (p>0.05, α=0.05 for all reservoirs).

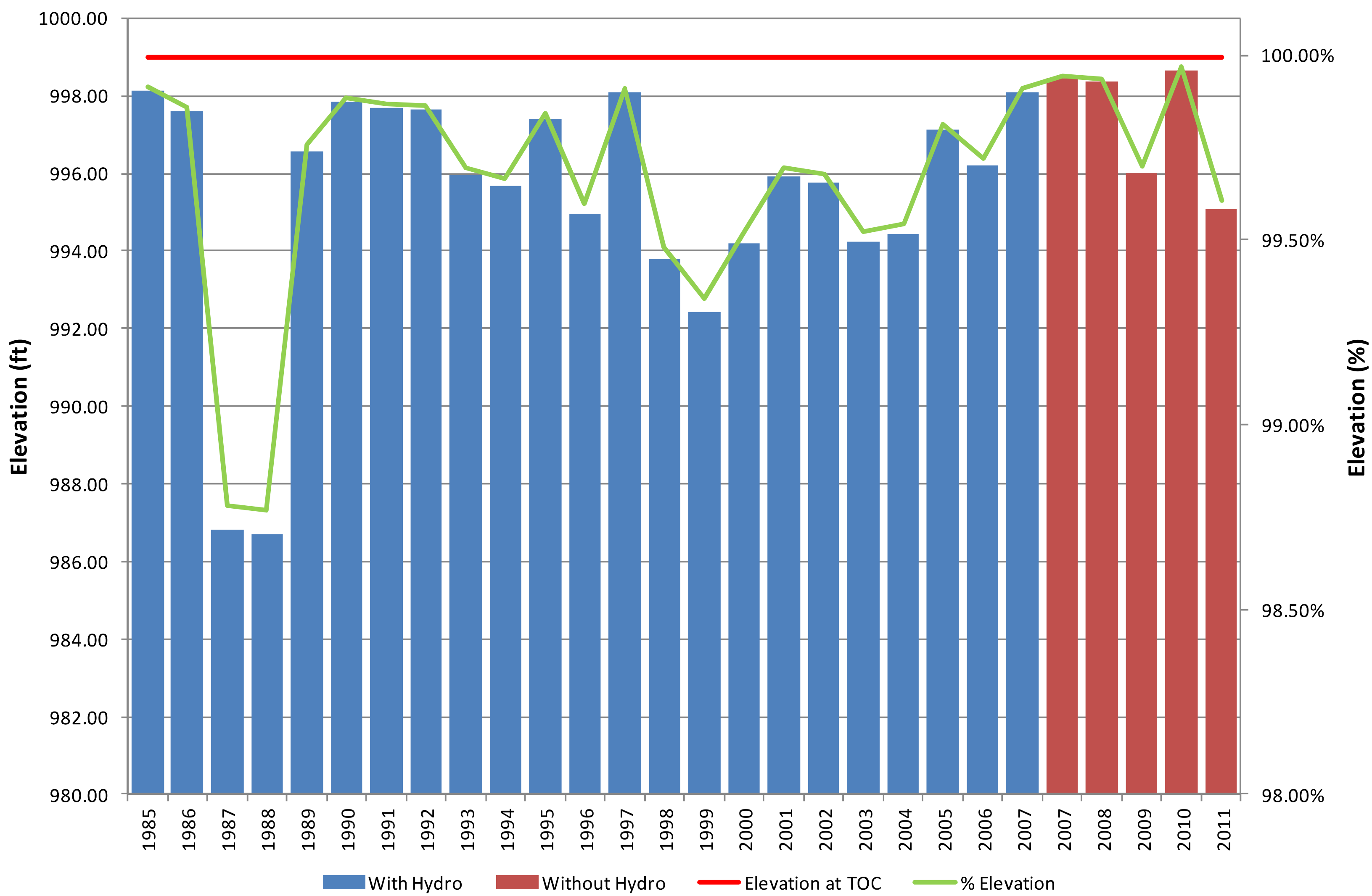



***Impact of Cessation of Hydroelectric Generation at Possum Kingdom on Mainstem Reservoirs***

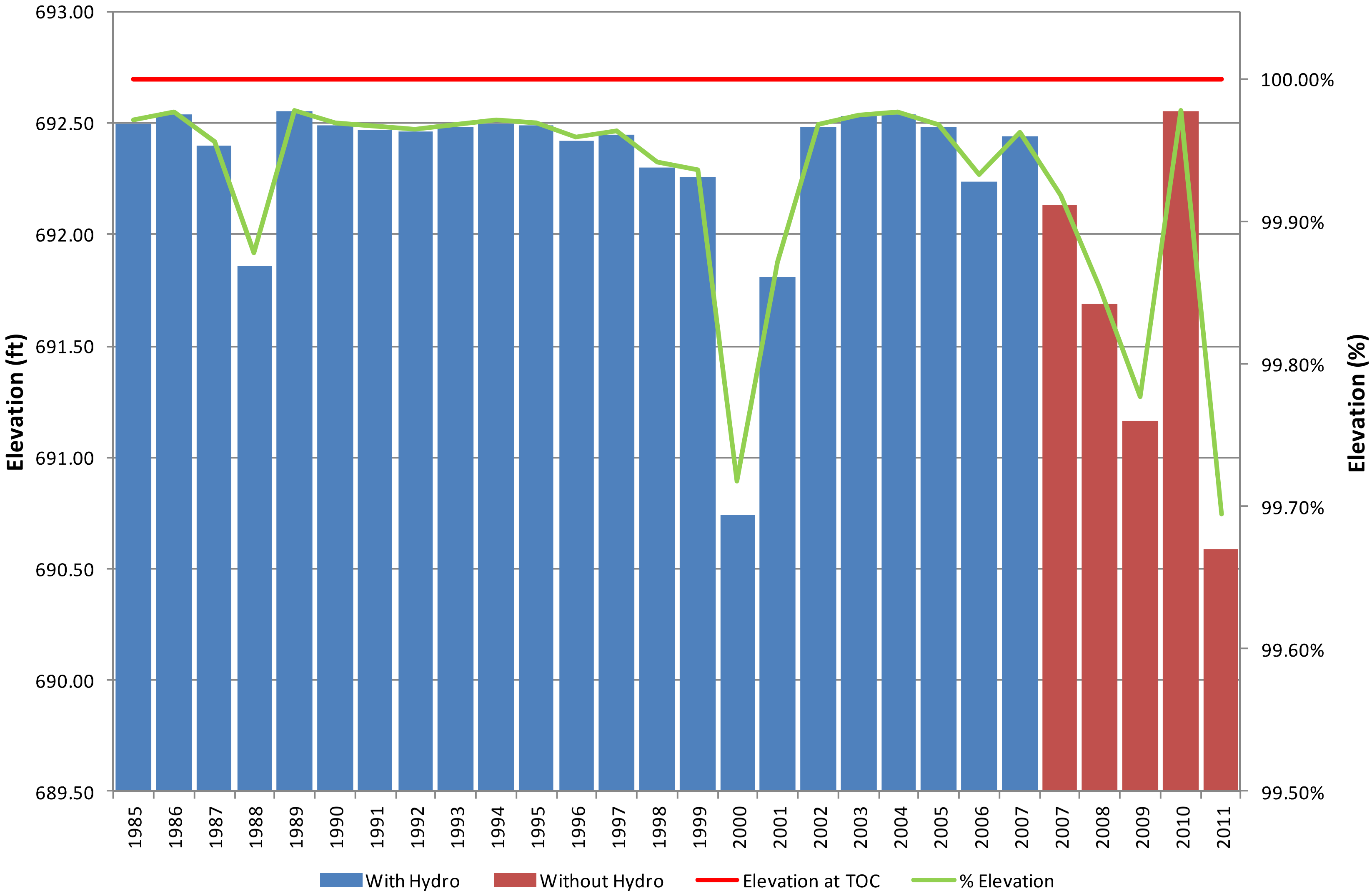
Hydroelectric generation ceased at Possum Kingdom in late 2007. Long-term changes to reservoir storage in Possum Kingdom, Granbury and Whitney, as a result of the cessation of hydroelectric generation, are difficult to predict given there are only four complete years of data, two of which were years of significant drought (2009 and 2011). Since cessation of hydroelectric generation there has been no significant change in median annual elevation across all mainstem reservoirs. In fact, median annual storage capacity at Possum Kingdom has increased slightly from 99.64% to 99.83% since the cessation of hydroelectric generation (Figure 2). At Granbury however, the median annual storage capacity has declined slightly (from 99.95% to 99.84%) since the cessation of hydroelectric generation at Possum Kingdom (Figure 3).

Due to the nature of USACE hydroelectric operations at Lake Whitney, it is not possible to clearly identify impacts to Whitney's median annual elevation directly resulting from cessation of hydroelectric generation at Possum Kingdom.

**Figure 2. Possum Kingdom Reservoir Annual, Median Elevation With and Without Hydroelectric Generation**



## Figure 3. Lake Granbury Annual, Median Elevation With and Without Hydroelectric Generation



### *Review of System Order 30% Rule*

The System Order requires the BRA to exclude a reservoir from System operation when the BRA's permitted storage in that reservoir is less than 30% full, so long as BRA permitted storage in any other System reservoir that can meet System needs is above 30% full. If and when all System reservoirs are below 30% full, normal System operations can continue. The 30% value was set to help protect supplies to meet local needs in times of drought. Protection of reservoir habitat was not a consideration when this provision was implemented. Proctor is the only System reservoir that has ever reached 30% of conservation pool capacity. During the 1999-2001 drought, Proctor fell below 30% capacity; however, it is used predominately for local water needs so there was no impact to System Operations. Based on historical records of the System reservoirs, frequent drawdowns below 30% capacities have not occurred. The 30% Rule is not a good indicator of habitat availability and potential impacts to fisheries. This is not surprising since this was not the intended purpose of the 30% Rule.

### *Reservoir-Specific Fisheries Data*

Species composition in most reservoirs in the Brazos River basin is composed of an assemblage of native riverine species and stocked species. Most reservoirs were initially stocked with hatchery-raised fish and many have been stocked throughout the reservoirs' lifetime to support recreational activities. Strategies frequently employed by TPWD to maintain optimal fisheries include: 1) stocking hatchery-produced fish; 2) enacting regulations to protect and enhance fish populations; and 3) managing aquatic habitat.

TPWD surveys the fisheries of each of the eleven System reservoirs in the Brazos River basin on a four-year assessment cycle. From these surveys, they produce a Performance Report for each reservoir summarizing the current status of the fishery and make recommendations for adjustments, if needed, to fishery management strategies. Reviews of recent Performance Reports for the System reservoirs indicate that the game-fish assemblages in all System reservoirs are largely composed of stocked species. Tables 1 and 2 provide a summary of historical fish stocking activities conducted by TPWD on System reservoirs. Of the total fish that have been stocked in System lakes: 99.96% are game species, 87% are species not native to the Brazos basin, and 62% are species that are not self-sustaining and whose populations must be maintained through stocking.

**Table 1. Gamefish Stocking Summary by Reservoir through 2011**

| Lake | Date of Impoundment | First Year Stocked | Last Year Stocked | Number of Years Stocked | Reservoir Impacted by Golden Algae | Native Species Stocked (%) | Must Be Maintained Through Stocking* (%) |
|---|---|---|---|---|---|---|---|
| Aquilla | 1983 | 1982 | 1985 | 4 | N | 5 | 26 |
| Belton | 1954 | 1967 | 2001 | 37 | N | 12 | 64 |
| Georgetown | 1980 | 1978 | 2011 | 20 | N | 39 | 8 |
| Granbury | 1969 | 1969 | 2010 | 31 | Y | 25 | 52 |
| Granger | 1980 | 1979 | 1996 | 9 | N | 52 | 7 |
| Limestone | 1978 | 1979 | 1998 | 7 | N | 53 | 17 |
| Possum Kingdom | 1941 | 1964 | 2011 | 40 | Y | 7 | 80 |
| Proctor | 1962 | 1970 | 2011 | 33 | N | 5 | 67 |
| Somerville | 1967 | 1967 | 2011 | 37 | N | 10 | 65 |
| Stillhouse Hollow | 1968 | 1968 | 2011 | 16 | N | 34 | 3 |
| Whitney | 1951 | 1966 | 2011 | 37 | Y | 7 | 60 |

*individual species populations w here natural reproduction in System reservoirs is negligible, the populations are not self-sustaining

Source: http://w w w .tpw d.state.tx.us/fishboat/fish/management/stocking/fishstock_w ater.phtml

Three reservoirs, Limestone, Aquilla and Granger, have not been stocked in over ten years due to habitat limitations and the fact that the species present in these reservoirs are self sustaining. Notably, Aquilla has not required stocking since 1985, three years after its impoundment.

**Table 2. Other Fish Species Stocking Summary by Reservoir Through 2011**

| Lake | Species | Year | Number Stocked |
|---|---|---|---|
| Possum Kingdom | Threadfin Shad | 1980 | 8,600 |
| Proctor | Green Sunfish X Redear Sunfish | 1971 | 5,000 |
| Proctor | Shad, Threadfin | 1984 | 1,000 |
| Whitney | Bluegill | 2005 | 13,747 |

Source: http://w w w .tpw d.state.tx.us/fishboat/fish/management/stocking/fishstock_state.phtml

Of the reservoirs that have been stocked in the last two years, three of them, Possum Kingdom, Granbury and Whitney, have been impacted by toxic golden alga events that have resulted in numerous fish kills. Over the past decade, intensive stocking of game fish has been undertaken by TPWD on these three reservoirs to mitigate the cumulative losses from golden alga fish kill events (TPWD 2008b, TPWD 2010a, TPWD 2011a).

The fisheries of Georgetown and Stillhouse Hollow are restricted due to poor habitat conditions (TPWD 2010b, TPWD 2010c). TPWD Performance Reports for both reservoirs note that limited aquatic vegetation and low primary productivity are two factors impacting the productivity and fish populations of these reservoirs.

Since 2002, Proctor has only been stocked with palmetto bass, a hybrid of the striped bass and white bass (TPWD 2010b). TPWD's decision to stock palmetto bass in Lake Proctor is a direct result of feedback from Lake Proctor anglers regarding the fishing preferences. Populations of palmetto bass must be maintained through stocking with hatchery-raised fingerlings because natural reproduction is negligible (TPWD 2006).

In the past 10 years, Somerville has also been stocked on an almost annual basis with palmetto bass (TPWD 2009). Florida largemouth bass have also been stocked three times in the last decade at Somerville. The most recent TPWD fisheries assessment indicates that recruitment of largemouth bass is high and the relative abundance has increased since the previous assessment. Also of note, during the 2008-2009 ShareLunker season, an angler caught and donated the first ever ShareLunker largemouth bass from Somerville. ShareLunkers are 13+ pound largemouth bass that are caught in the wild then donated by anglers to TPWD hatcheries to improve largemouth bass population genetics.

Table 3 summarizes forage fish data from each System reservoir. With the exception of Whitney, forage species have not been stocked in any of the System reservoirs in over 25 years. Whitney was stocked with bluegill in 2005 after a series of toxic golden alga events that occurred from 2001 through 2004. The 2003 outbreak resulted in significant mortality of all fish species from the headwaters almost to the dam in Whitney (TPWD 2004).

The index of vulnerability (IOV) for gizzard shad is the percentage of the gizzard shad population that is ≤8 inches in length that are vulnerable to predation. On all but two lakes the IOV exceeded 80%, indicating most of the shad are of a size that can be used as forage by most game fish (Table 3). The IOV for both Georgetown and Stillhouse Hollow was 50%. The prey base at Stillhouse Hollow is cited to be very weak in the

2010 Reservoir Performance Report, likely due to a lack of aquatic vegetation as a result of the prolonged retention of flood waters in 2007. The littoral zone of Lake Georgetown consists primarily of limestone bluffs, bedrock, and rocky substrate. This, in addition to very low nutrient concentrations, hinders the development of aquatic vegetation. Due to marginal aquatic vegetation availability, the fishery in Lake Georgetown will remain limited, compared to other System reservoirs. However, the gizzard shad IOV of 50% documented on Lake Georgetown in 2009 represents an increase in available gizzard shad from the previous two assessments in 2005 and 2001. If this increasing trend continues, it may result in an improvement to the fishery in Lake Georgetown, by providing additional forage fish numbers.

The lack of recent forage species stocking (except in response to toxic golden alga events) and high gizzard shad IOVs indicate that the forage fish assemblage in System

**Table 3. TPWD Catch Rate Status for Forage Species in Most Recent Performance Report**

| Lake | Last Year Assessed | Threadfin Shad | Gizzard Shad | Bluegill | Longear Sunfish | Redear Sunfish | Warmouth | Green Sunfish | Gizzard Shad IOV |
|---|---|---|---|---|---|---|---|---|---|
| Aquilla | 2010 | ↔ | ↔ | ↓ | | | | | 84% |
| Belton | 2010 | ↑ | ↑ | ↓ | | | | | 86% |
| Georgetown | 2009 | | ↑ | ↓ | | | | | 50% |
| Granbury | 2009 | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | 95% |
| Granger | 2008 | ↑ | ↓ | ↑ | ↔ | ↔ | ↔ | | 92% |
| Limestone | 2008 | ↑ | ↓ | ↑ | ↑ | ↑ | ↑ | | 85% |
| Possum Kingdom | 2010 | ↓ | ↓ | ↓ | | | | | 82% |
| Proctor | 2010 | | ↑ | ↑ | | | | | 99% |
| Somerville | 2008 | ↑ | ↓ | ↓ | | | | | 99% |
| Stillhouse Hollow* | 2009 | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | 50% |
| Whitney | 2007 | ↑ | ↑ | ↔ | | | | | 91% |

Catch rate change from previous assessments: ↑ = increase, ↓ = decrease, ↔ = no significant difference

* decline in forage fish numbers attributed to the loss of hydrilla, the only significant vegetation, as a result of flooding in 2007

reservoirs appears to be self-sustaining, resilient to changing environmental conditions, and adequate to support game fish populations.

An attempt to identify impacts of fluctuating water levels on the fisheries data reported in TPWD's Performance Reports was hindered by a lack of significant differences in reservoir elevations throughout the period analyzed, limited fishery information, and the inability to clearly separate the impacts of stocking activities and biotic disturbances on System reservoir fisheries.

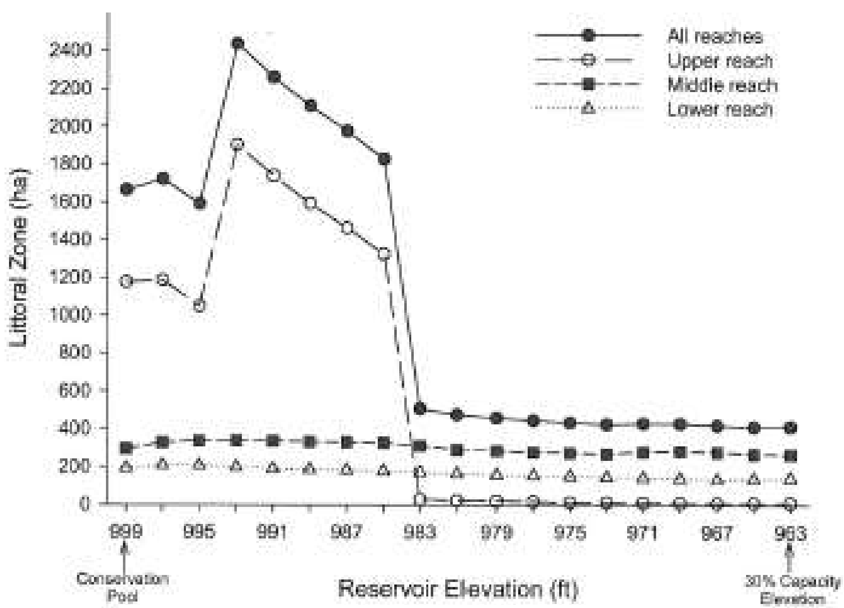
### *Littoral Habitat Availability*

**Table 4. Littoral Zone Depth by Reservoir**

| Reservoir | Littoral Zone Depth (ft) |
|---|---|
| Aquilla | 4 |
| Belton | 8 |
| Georgetown | 6 |
| Granbury | 6 |
| Granger | 2 |
| Limestone | 4 |
| Possum Kingdom | 10 |
| Proctor | 6 |
| Somerville | 14 |
| Stillhouse Hollow | 12 |
| Whitney | 8 |

The littoral zone depth examined at each level of reservoir elevation is listed by reservoir in Table 4. As expected, declines in littoral zone habitat were observed with decreasing water levels. The upper region of each reservoir exhibited the greatest loss in littoral area with declining water levels. In general, the littoral zone in the middle and lower reaches of System reservoirs increased or remained consistent with reductions in water levels. An example of this is depicted in elevation (Figure 4) using data from Possum Kingdom Reservoir. (The littoral habitat availability charts for each System reservoir can be found in Appendix B).

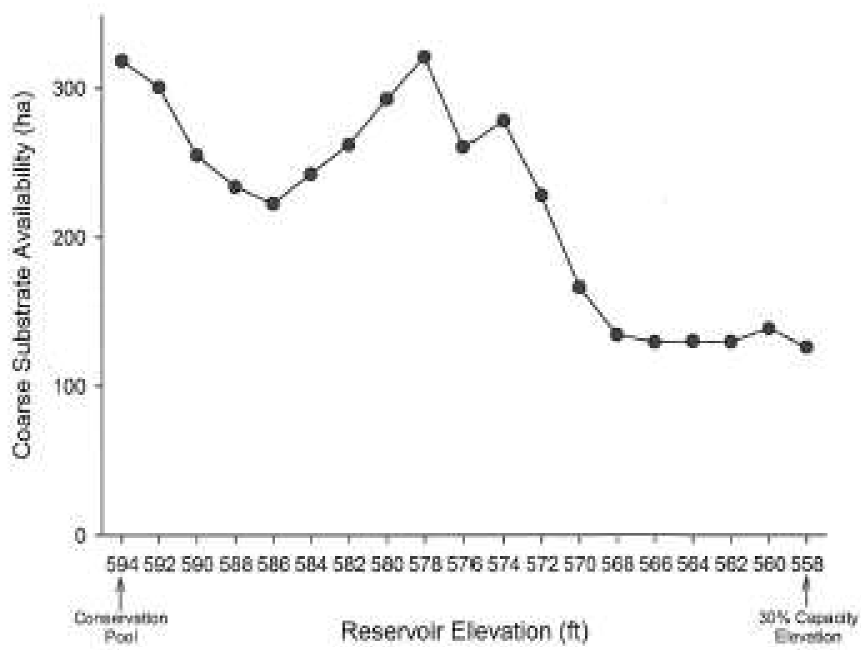
Figure 4. Elevation specific littoral zone (< 10 ft. water depth) coverage in Possum Kingdom Reservoir, Texas, for upper, middle, and lower reservoir reaches and all reaches combined.




Source: Texas Parks and Wildlife Inland Fisheries Division

In Aquilla, Georgetown, Granbury, Somerville, Stillhouse Hollow and Whitney, high-quality littoral substrate (e.g. gravel, cobble or boulder substrates) declined with reductions in water levels. However, Belton, Granger, Limestone, Possum Kingdom and Proctor are exceptions. All five reservoirs follow a similar coarse substrate pattern to that in Belton, where coarse substrate coverage declined steadily to approximately 210 ha at an elevation of 586 ft. From elevation 584 ft. through elevation 574 ft. the coarse substrate availability on Lake Belton increased above 210 ha, before beginning to decline again at an elevation of 572 ft (Figure 5; coarse substrate availability charts by reservoir are included in Appendix B).

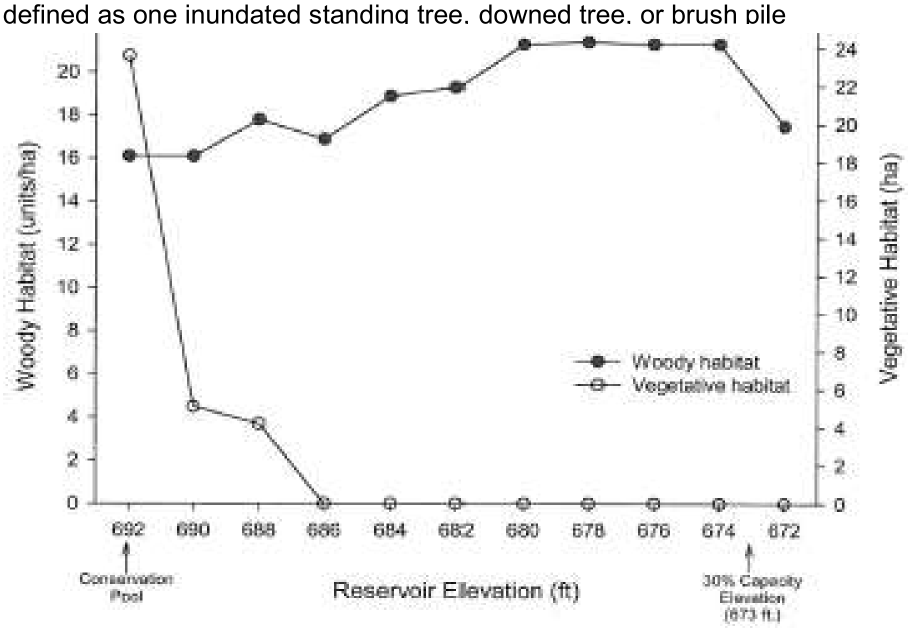
Figure 5. Elevation specific littoral zone (< 8 ft. water depth) coarse substrate availability in Lake Belton, Texas.




Source: Texas Parks and Wildlife Department Inland Fisheries

The amount of littoral habitat generated by herbaceous vegetation declined with decreasing water levels in all reservoirs, except for Georgetown. Georgetown is the only System reservoir where no herbaceous vegetation was detected. While herbaceous vegetation trends were consistent across System reservoirs, the amount of high-quality littoral habitat generated by woody vegetation is variable across reservoirs and water levels. In Georgetown, Limestone, Stillhouse Hollow, and Whitney, woody habitat availability remained fairly consistent across the range of pool heights examined. While in Aquilla, Belton, Granbury, Granger and Possum Kingdom woody habitat availability increased as reservoir elevation declined (Figure 6, for Lake Granbury; vegetation habitat availability charts by reservoir are included in Appendix B). In Proctor and Somerville, woody vegetation followed the same trend as herbaceous vegetation, with declining coverage with declining water levels.

Figure 6. Elevation specific littoral zone (< 6 ft. water depth) woody and vegetative habitat availability in Lake Granbury, Texas. Woody habitat was defined as one inundated standing tree, downed tree, or brush pile




Source: Texas Parks and Wildlife Inland Fisheries

Recreational access was highly variable across System reservoirs; with some losing access with as little as a 6 ft. reduction in lake level and others not losing access until more than a 20 ft. reduction in lake elevation. Table 5 displays recreational access data by reservoir.

| Table 5. Elevation Specific Public Boat Launch Accessibility by Reservoir | | | |
|---|---|---|---|
| **Reservoir** | **Number of Public Boat Launches** | **Elevation Where Public Boat Launches are No Longer Accessible (ft)** | **Drawdown from TOC (ft)** |
| Aquilla | 2 | 528* | -10 |
| Belton | 13 | 572* | -22 |
| Georgetown | 3 | 769* | -22 |
| Granbury | 5 | 685.9** | -7.1 |
| Granger | 4 | 494* | -10 |
| Limestone | 5 | 355.5** | -7.5 |
| Possum Kingdom | 8 | 991.5** | -7.5 |
| Proctor | 7 | 1154* | -8 |
| Somerville | 13 | 228*** | -10 |
| Stillhouse Hollow | 3 | 594* | -28 |
| Whitney | 20 | 512* | -21 |

* Source: TPWD Inland Fisheries Division, terminus of launch + 2 feet

** Source: BRA Lake Manager

***Source TPWD Inland Fisheries Division, tw o public boat launches assessible to 30% capacity elevation (226 ft.)

### *Threshold Determinations*

Threshold elevations were determined based upon species of importance and limiting habitat element or elements of each individual System reservoir. The species of importance and limiting habitat elements for those species were identified by TPWD Inland Fisheries staff (Table 6). The threshold elevations agreed to by both TPWD Inland Fisheries staff and BRA are listed in Table 7. As an example, Figures 7 and 8 display the difference in reservoir storage between top of conservation pool (TOC) and when the lake level is at the threshold for Lake Aquilla. (Similar maps for other reservoirs are included in Appendix C).

| Table 6. Species of Importance and Limiting Habitat Elements by System Reservoir | | |
|---|---|---|
| **Reservoir** | **Species of importance** | **Limiting Habitat Element** |
| Aquilla | White crappie, Catfish | Coarse substrate and vegetation |
| Belton | Largemouth and Smallmouth bass, Palmetto bass, Catfish | Coarse substrate and littoral zone |
| Georgetown | Largemouth bass, White bass, Palmetto bass, Catfish | Coarse substrate |
| Granbury | Largemouth bass, Striped bass, Catfish | Coarse substrate and littoral zone |
| Granger | White crappie, Catfish, White bass | Connectivity with river and creeks |
| Limestone | Largemouth bass, White bass, White crappie, Catfish | Coarse substrate and vegetation |
| PK | Largemouth Bass, White bass, Striped bass | Vegetation and river connectivity |
| Proctor | White bass, Palmetto bass, Largemouth bass, Catfish | Littoral zone and woody habitat |
| Somerville | White bass, White crappie, Catfish, Largemouth bass | Coarse substrate and vegetation |
| Stillhouse | Largemouth bass, White bass, Catfish | Vegetation |
| Whitney | Striped bass, Largemouth and Smallmouth bass, Catfish | Vegetation and littoral zone |

| Table 7. Threshold Elevation by System Reservoir | | | |
|---|---|---|---|
| **Reservoir** | **TOC (ft-msl)** | **Threshold Elevation (ft-msl)** | **Drawdown from TOC (ft)** |
| Aquilla | 538 | 536 | -2 |
| Belton | 594 | 578 | -16 |
| Georgetown | 791 | 787 | -4 |
| Granbury | 693 | 690 | -3 |
| Granger | 504 | 504 | 0 |
| Limestone | 363 | 358 | -5 |
| PK | 999 | 995 | -4 |
| Proctor | 1162 | 1158 | -4 |
| Somerville | 238 | 236 | -2 |
| Stillhouse | 622 | 610 | -12 |
| Whitney | 533 | 526 | -7 |

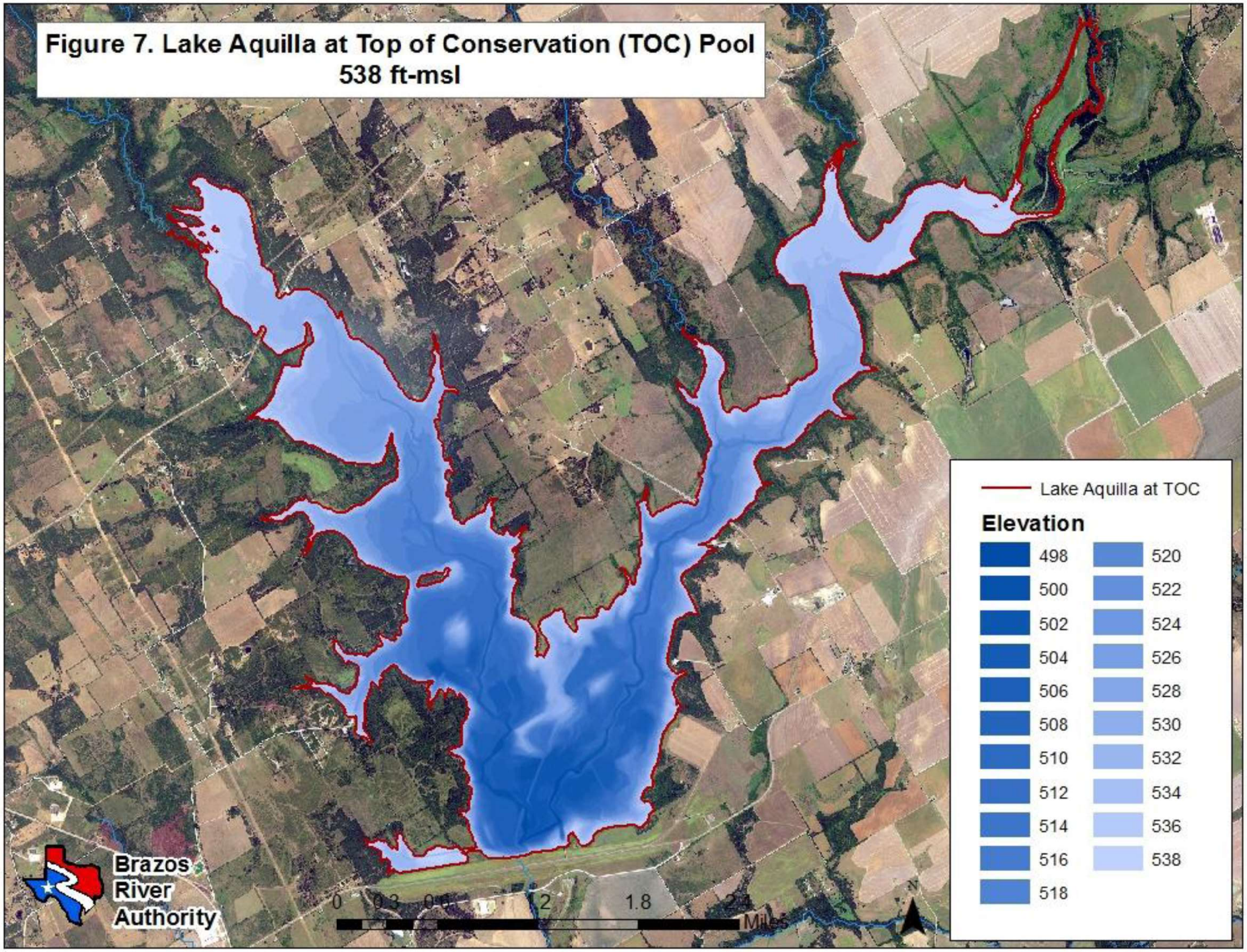


Figure 7. Lake Aquilla at Top of Conservation (TOC) Pool
538 ft-msl
Lake Aquilla at TOC
Elevation
498
500
502
504
506
508
510
512
514
516
518
520
522
524
526
528
530
532
534
536
538
0
0.3
0.6
1.2
1.8
2.4
Miles
N
Brazos River Authority

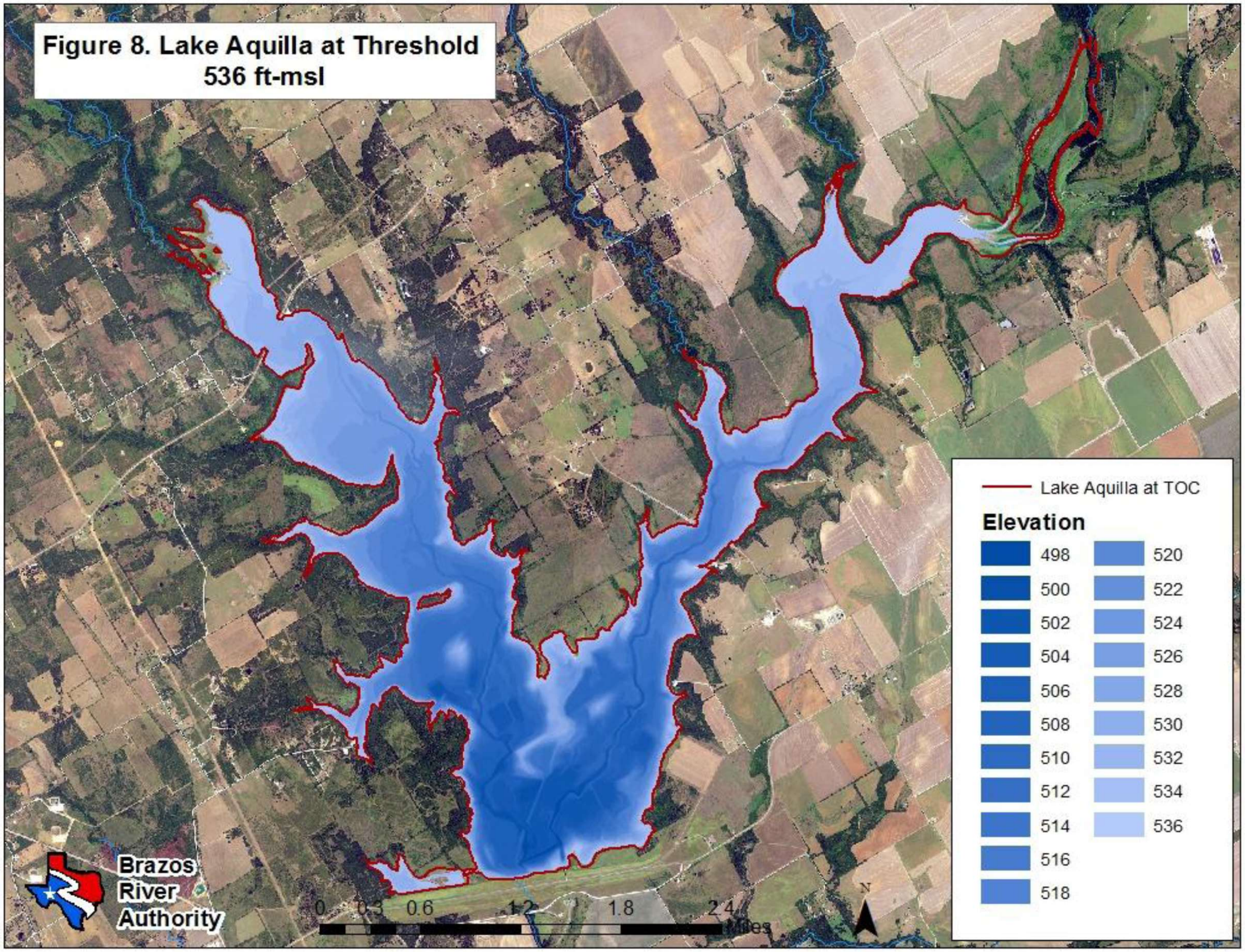


Figure 8. Lake Aquilla at Threshold
536 ft-msl
Lake Aquilla at TOC
Elevation
498
500
502
504
506
508
510
512
514
516
518
520
522
524
526
528
530
532
534
536
0
0.3
0.6
1.2
1.8
2.4
Miles
N
Brazos
River
Authority

### *Historical and Predicted Attainment of Thresholds by System Reservoir*

A review of historical surface elevation data (Jan 1985 - Jan 2012) for each System reservoir reveals that no reservoir has been below its threshold elevation continuously for three years. From April 1987 through May 1989, Possum Kingdom Lake was intentionally drawn down 13 feet for a duration of 773 consecutive days to complete an extensive dam rehabilitation project. The next longest drawdown of one of the System reservoirs occurred at Lake Proctor from July 1999 through February 2001 and was a result of drought conditions. This event lasted for 604 consecutive days and is now considered the drought of record for Lake Proctor.

In 2011, for the first time all System reservoirs experienced at least one drawdown below their respective thresholds. The 2011 drought was summarized by the Texas State Climatologist as, "…the most intense one-year drought in Texas since at least 1895 when statewide weather records begin, and though it is difficult to compare droughts of different durations, it probably already ranks among the five worst droughts overall. The statewide drought index value has surpassed all previous values, and it has been at least forty years since anything close to the severity of the present drought has been experienced across Texas." (Nielsen-Gammon 2011).

Lake trace and frequency diagrams for the three WAM Scenarios described above can be located in Appendix D. WAM scenario results are presented in the following discussion of each individual reservoir.

### *Lake Aquilla*

Historically, Aquilla water levels have been below the threshold 23% of the time (Figure 9). It has experienced 34 drawdown events below threshold, ranging in duration from 1 day to 571 consecutive days (Figure 10). Recreational access to the reservoir has not been impeded historically due to low water levels.

WAM results for Aquilla reveal that under current conditions, Scenario 1, Aquilla elevations are expected to equal or exceed the threshold 64.7% of the time. Under Scenario 2, elevations are expected to equal or exceed the threshold 60.0% of the time. There is no difference for Aquilla between Scenarios 2 and 3. The public recreational access elevation for Aquilla is equaled or exceeded 99.5% of the time in Scenario 1 and 97.3% of the time in Scenarios 2 and 3.

**Figure 9. Historical Occurrence of Threshold Elevation on Lake Aquilla**

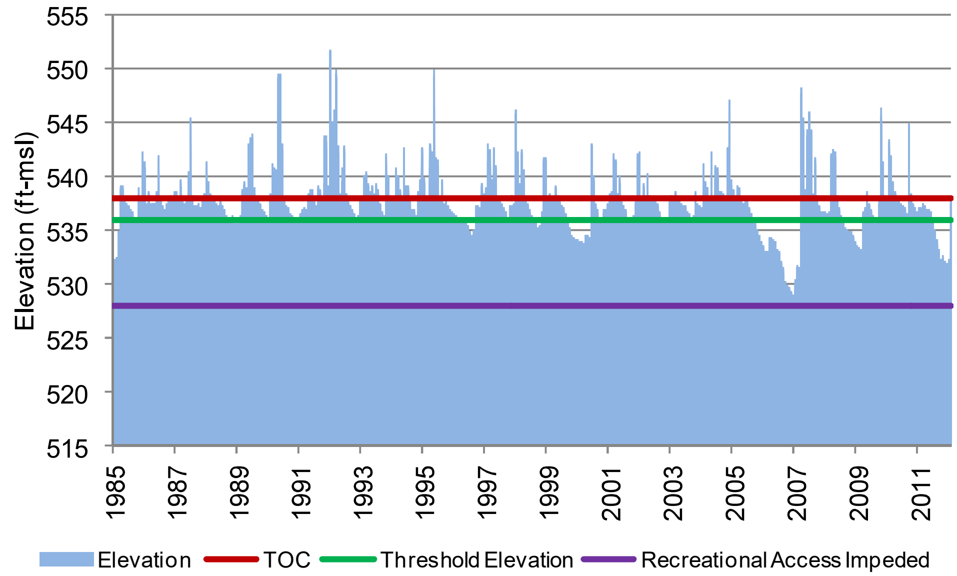
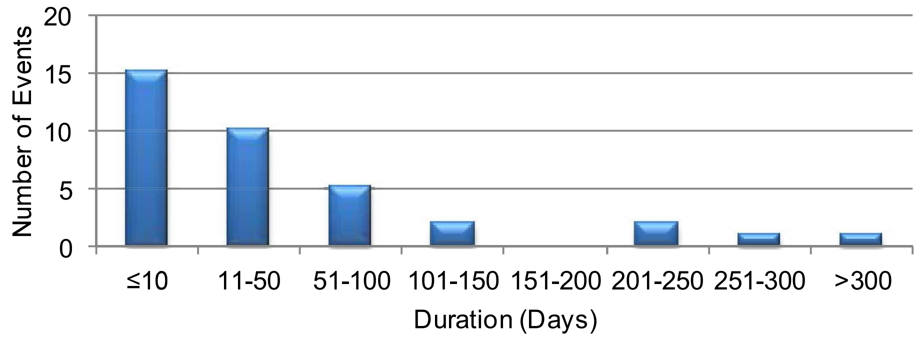


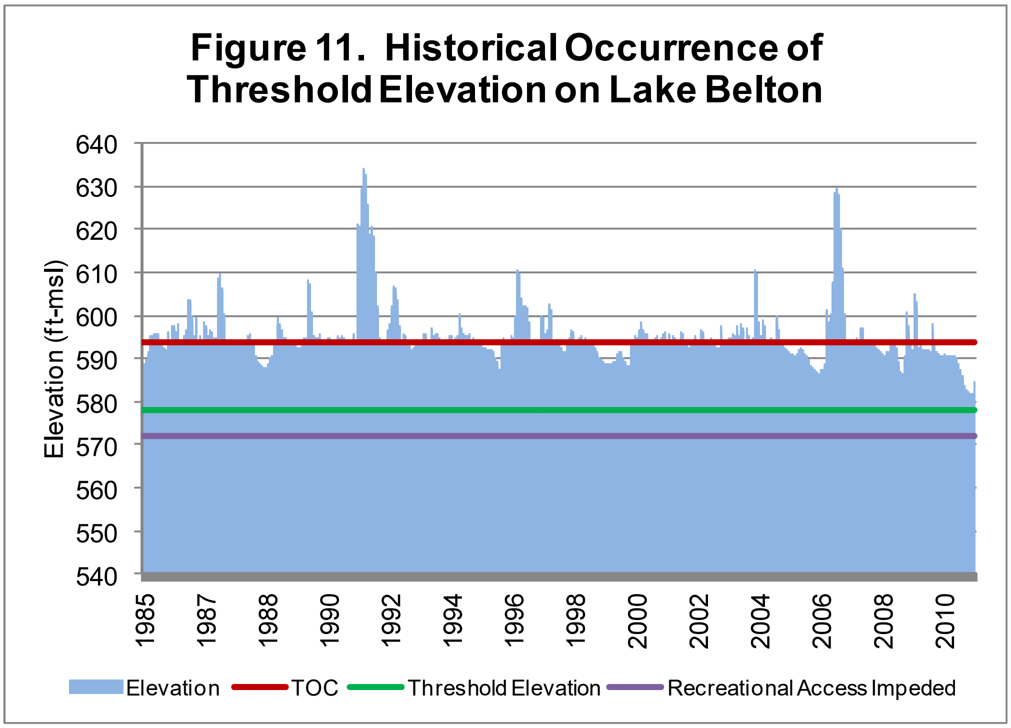

**Figure 10. Lake Aquilla Duration Frequency of Historical Events Below Threshold**




***Lake Belton***

Review of littoral habitat availability data and fisheries data reveals that Belton is one of the most resilient reservoirs in the System where the fishery can withstand up to a 16-foot drawdown before high-quality littoral habitat is degraded. A review of historical surface elevation data for Belton reveals that the reservoir's surface elevation has not been below the threshold and that recreational access to the reservoir has not been impeded due to low water levels (Figure 11).

WAM results for Belton reveal that under Scenario 1, elevations are expected to equal or exceed the threshold 93.9% of the time. Under Scenario 2, elevations are expected to equal or exceed the threshold 94.8% of the time and under Scenario 3, elevations are expected to equal or exceed the threshold 95.1% of the time. The public recreational access elevation for Belton is equaled or exceeded 96.7% of the time in Scenario 1 and 98.5% and 98.1% of the time in Scenarios 2 and 3, respectively.

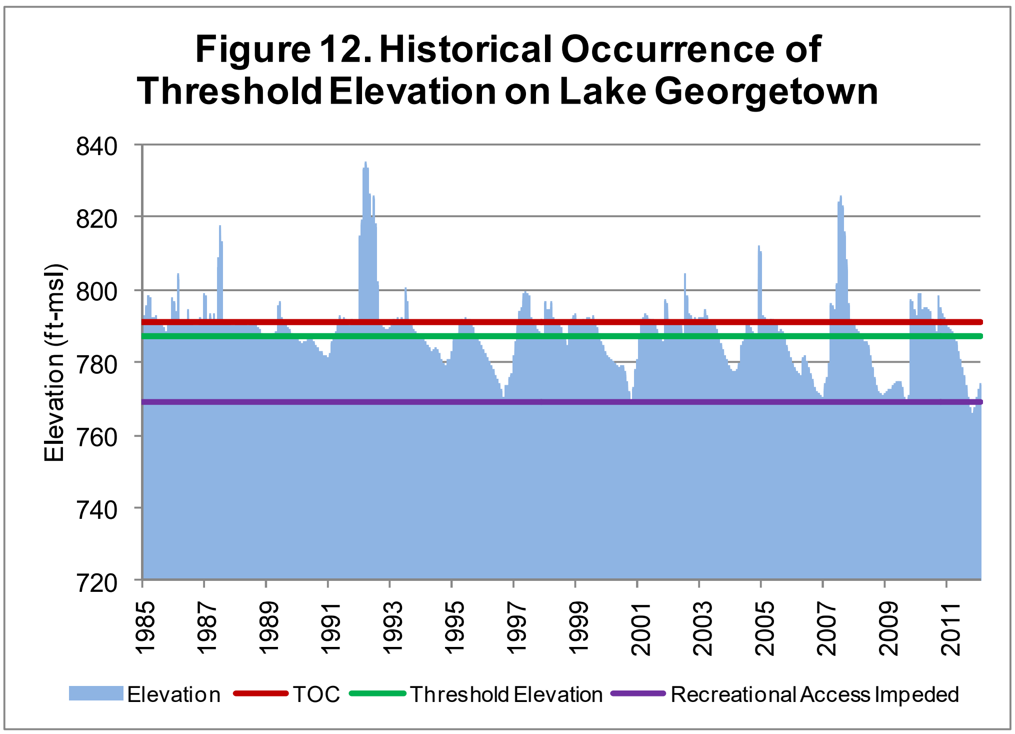


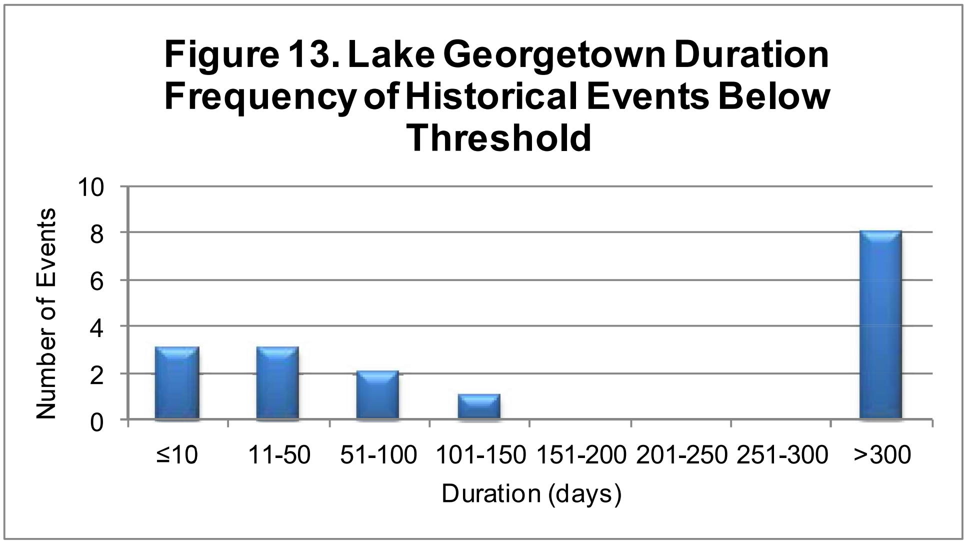

***Lake Georgetown***

Georgetown experiences frequently fluctuating water levels due to its small storage capacity, the flashy nature of its watershed and high local reliance of nearby communities on the lake for water supply purposes. Littoral habitat in Georgetown is limited due to shoreline habitat that consists primarily of rocky shoreline and rock bluffs which inhibit the establishment of aquatic vegetation. Littoral habitat declines in Georgetown with a drawdown of four feet.

Historical reservoir levels are below the threshold 40% of the time (Figure 12). The total number of occurrences below the threshold is 17, with the longest occurrence lasting 591 consecutive days (Figure 13). Recreational access to the reservoir is impeded at a drawdown of 22 feet and angler access has been impeded 1.5% of the time during the historical period evaluated.

WAM results for Georgetown reveal that under Scenario 1, elevations are expected to equal or exceed the threshold 37.9% of the time. Under Scenario 2, elevations are expected to equal or exceed the threshold 32.3% of the time and 32.6% of the time under Scenario 3. The public recreational access elevation for Georgetown is equaled or exceeded 100% of the time in all Scenarios.

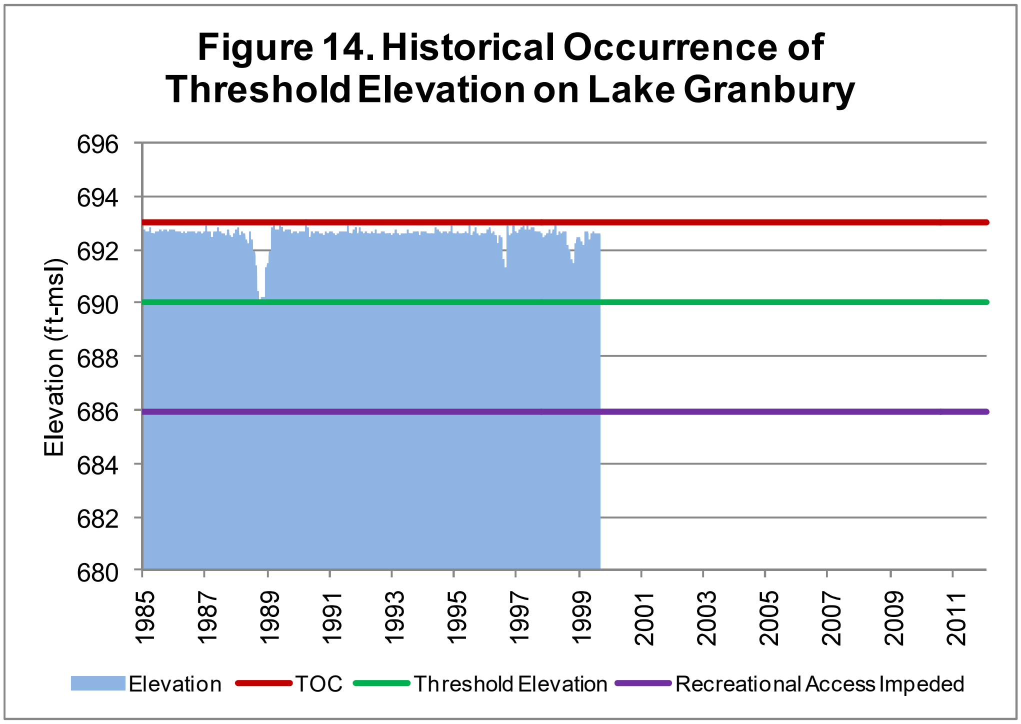


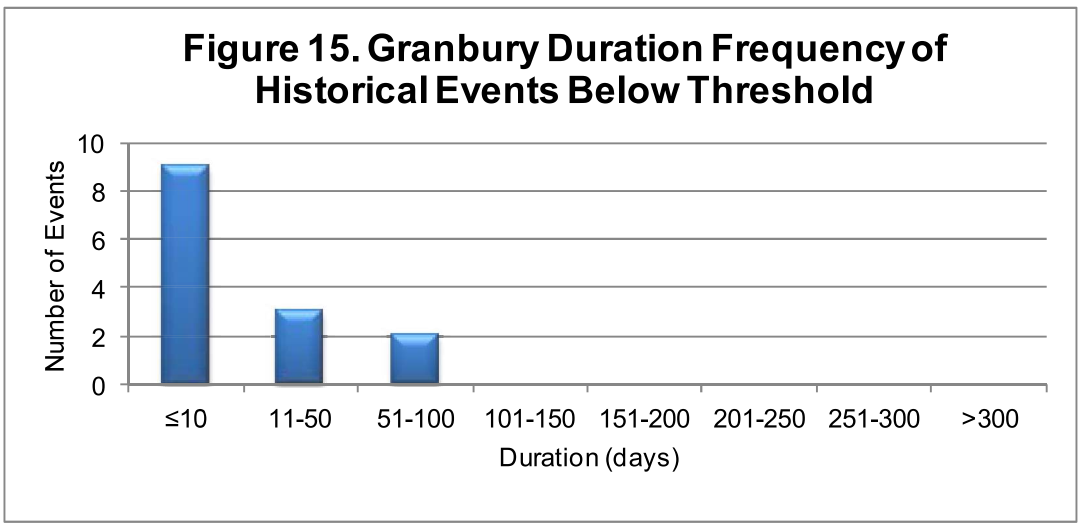



***Lake Granbury***

Littoral habitat declines in Granbury with a drawdown of three feet (Figure 14). A review of historical surface elevation data for Granbury reveals that the reservoir's surface elevation has been below the recommended threshold 3% of the time. The total number of occurrences below the threshold is 13, with the longest occurrence lasting 92 consecutive days (Figure 15). Recreational access to the reservoir is impeded at a drawdown of approximately seven feet. Water level drawdowns that impede public access to the reservoir have occurred once during the historical period evaluated, for four consecutive days from September 28, 2011 through October 1, 2011. To improve recreational access, the BRA is currently working to extend the length of the boat ramp at DeCordova Bend Park by 25 feet.

WAM results for Granbury reveal that under Scenario 1, elevations are expected to equal or exceed the threshold 96.5% of the time. Under Scenario 2, elevations are expected to equal or exceed the threshold 96.8% of the time and under Scenario 3, elevations are expected to equal or exceed the threshold 91.5% of the time. The public recreational access elevation for Granbury is equaled or exceeded 100% of the time in Scenario 1, 99.3% of the time in Scenario 2, and 98.7% of the time in Scenario 3.



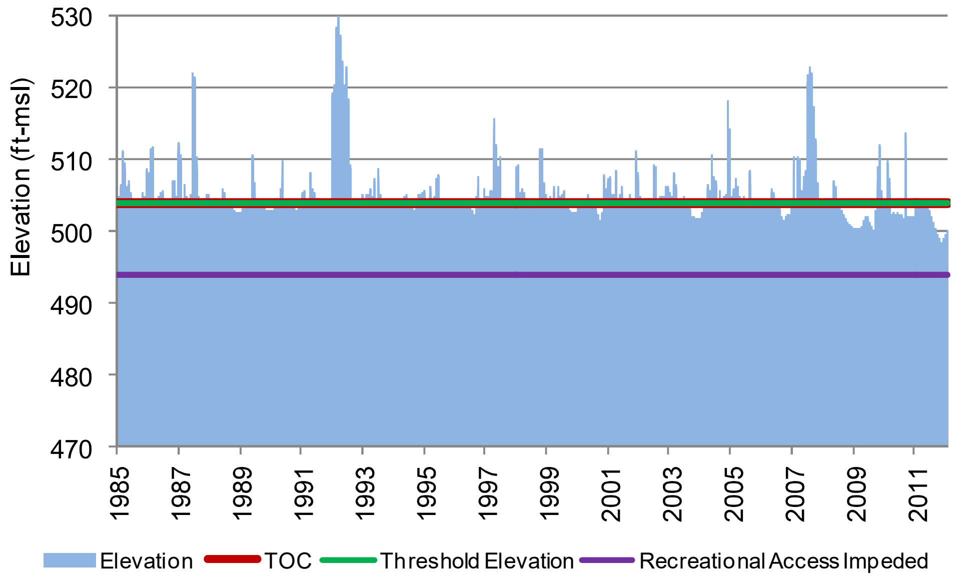

***Lake Granger***

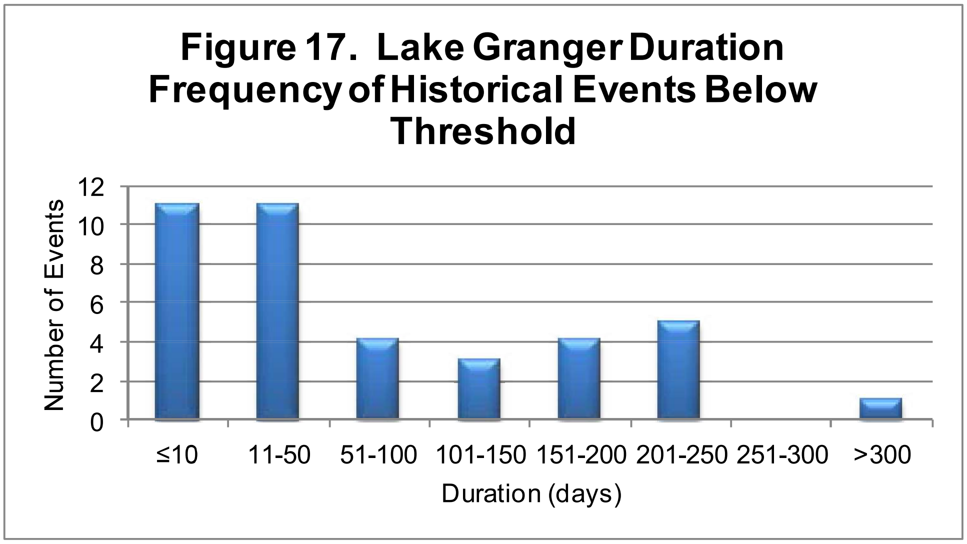
The threshold for Granger is equal to the reservoir's TOC elevation, so any water level below full results in loss of littoral habitat. This is primarily a result of issues with connectivity to the San Gabriel River and the importance of white bass in the reservoir. White bass and crappie migrate from lakes up river to spawn, given the shallow nature of the headwaters of the reservoir and the San Gabriel River; it is not uncommon for the two to lose connectivity during dry years, thus inhibiting the reproductive success of the two species.

Despite its shallow nature and susceptibility to drought, Granger, exceeds its threshold elevation 65% of the time (Figure 16). It has experienced 36 drawdown events below threshold, ranging in duration from 1 day to 478 consecutive days (Figure 17). A review of historical surface elevation data reveals that recreational access to the reservoir has not been impeded due to low water levels during the historical period evaluated.

WAM results for Granger reveal that under Scenario 1, elevations are expected to equal or exceed the threshold 58.8% of the time. Under Scenario 2, elevations are expected to equal or exceed the threshold 52.4% of the time and under Scenario 3, elevations are expected to equal or exceed the threshold 63.5% of the time. The public recreational access elevation for Granger is equaled or exceeded 98.1% of the time in Scenario 1, 99.4% of the time in Scenario 2, and 99.6% of the time in Scenario 3.

**Figure 16. Historical Occurrence of Threshold Elevation on Lake Granger**

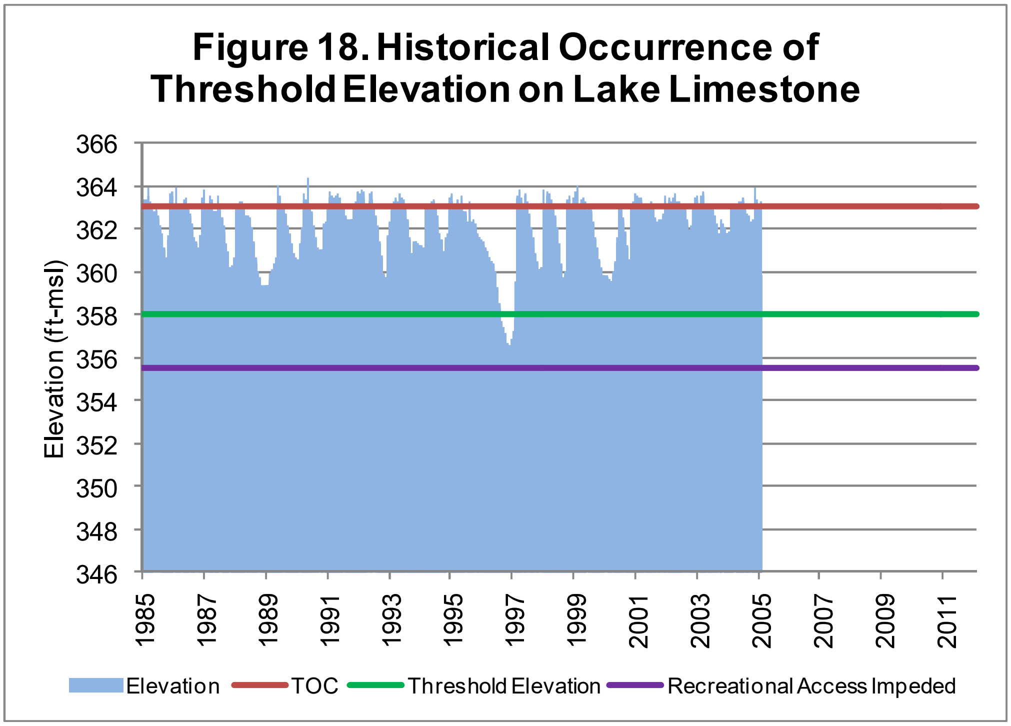





***Lake Limestone***

Littoral habitat declines in Limestone with a drawdown of five feet (Figure 18). A review of historical surface elevation data for Limestone reveals that the reservoir's surface elevation has been below the recommended threshold 4% of the time. The total number of occurrences below the threshold is two, with each occurrence lasting roughly 195 consecutive days. Recreational access to the reservoir is impeded at a drawdown of six feet and has been impeded once for 150 consecutive days, from August 28, 2011 through January 24, 2012.

WAM results for Limestone reveal that under Scenario 1, elevations are expected to equal or exceed the threshold 80.8% of the time. Under Scenarios 2 and 3, elevations are expected to equal or exceed the threshold 81.7% and 81.8%of the time, respectively. The public recreational access elevation for Limestone is equaled or exceeded 87.2% of the time in Scenario 1, 87.5% of the time in Scenario 2, and 87.7% of the time in Scenario 3.

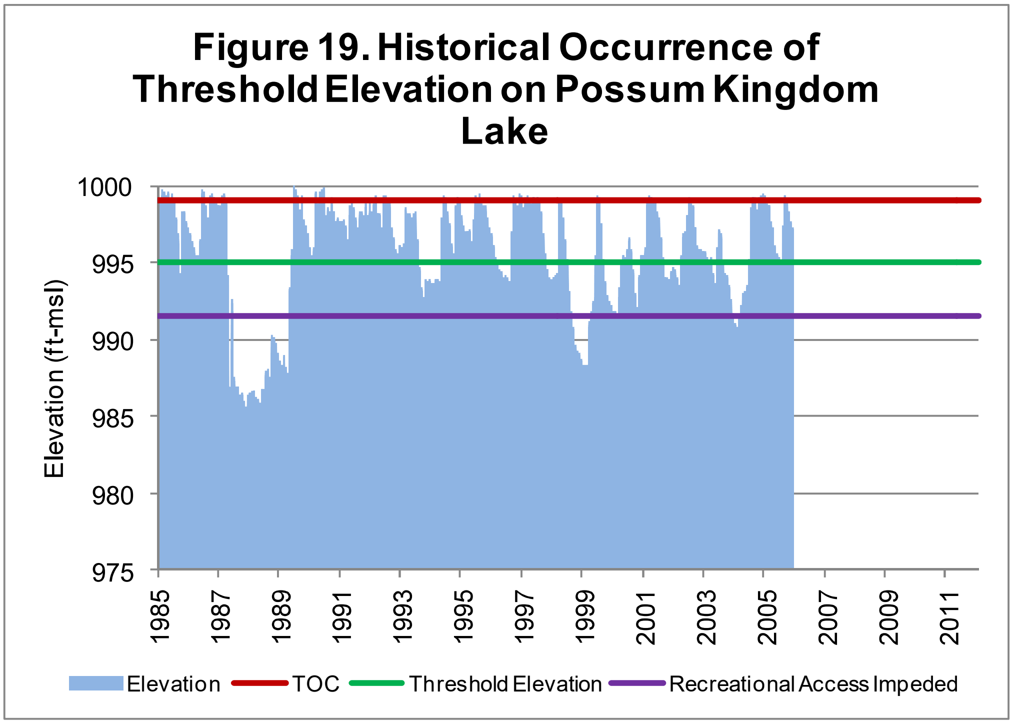


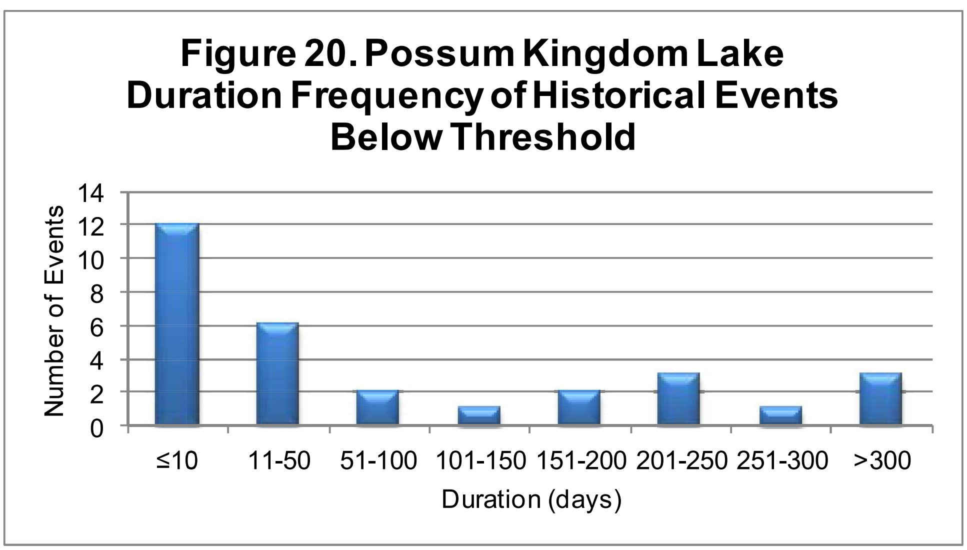

***Possum Kingdom Lake***

Review of littoral habitat availability data reveals that Possum Kingdom exceeds its threshold elevation 67% of the time (Figure 19). However, between April 1987 and May 1989, the reservoir level was intentionally drawn down 13 feet for 773 consecutive days, for a dam rehabilitation project. This intentional drawdown accounts for 8% of the elevations recorded that are below the threshold elevation. When data from the intentional drawdown is removed, Possum Kingdom exceeds its threshold elevation 75% of the time. Possum Kingdom's elevation has been below the threshold a total of 30 times, ranging from 1 day to 773 consecutive days (Figure 20).

A review of historical surface elevation data for Possum Kingdom reveals that recreational access to the reservoir has been impeded due to low water levels 13% of the time when lake levels from the intentional drawdown are included, and 6% of the time when data from the intentional drawdown is removed from the analysis. To improve recreational access to Possum Kingdom, the BRA extended the length of both the South D&D Park and North D&D Park boat ramps in FY 2012, by 53 feet and 45 feet respectively. In FY 2013, the BRA is planning to extend the boat ramps at Sandy Creek Park and Scenic Cove Park.

WAM results for Possum Kingdom reveal that under Scenario 1, elevations are expected to equal or exceed the threshold 97.8% of the time. Under Scenario 2, elevations are expected to equal or exceed the threshold 96.1% of the time and under Scenario 3, elevations are expected to equal or exceed the threshold 91.7% of the time. The public recreational access elevation for Possum Kingdom is equaled or exceeded 99% of the time in Scenario 1, 97.9% of the time in Scenario 2, and 98.8% of the time in Scenario 3.



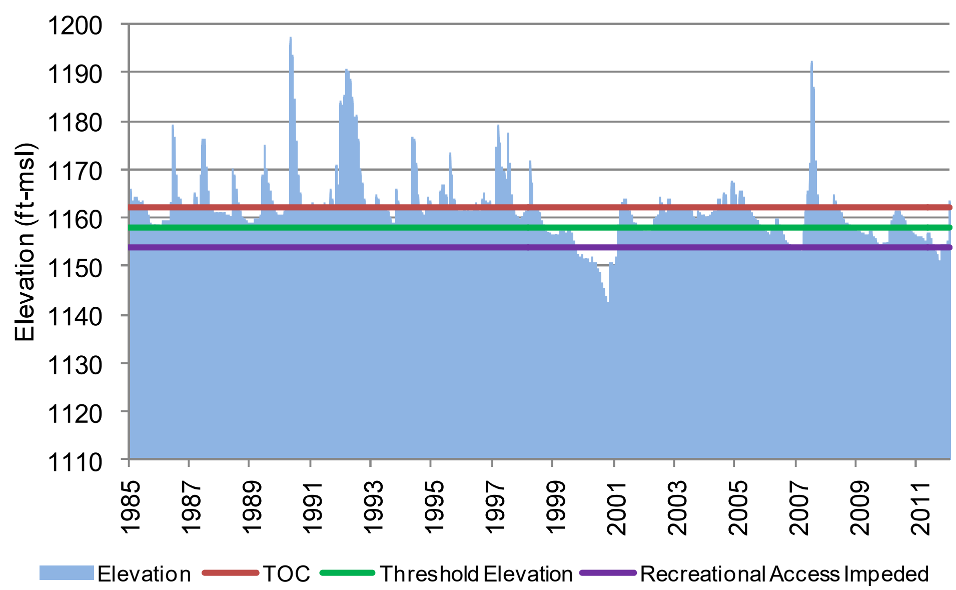



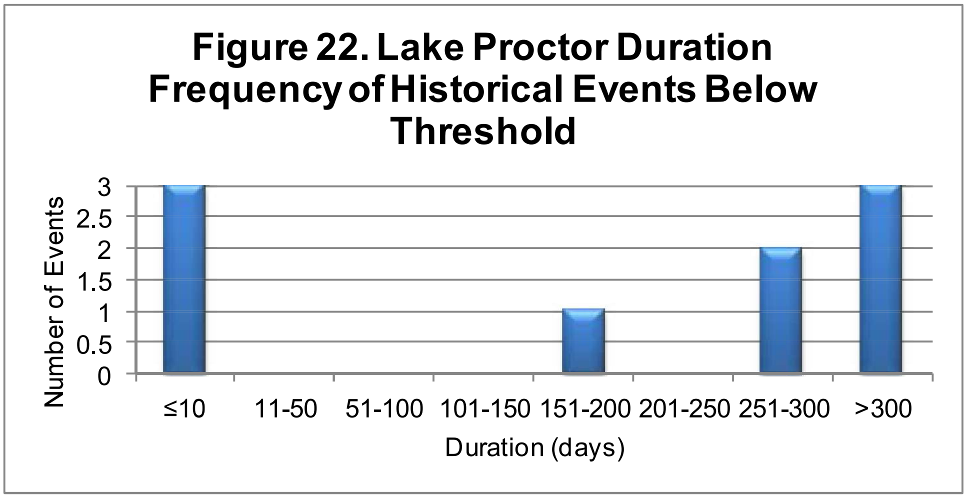
***Lake Proctor***

Proctor often experiences drawdowns below the threshold in dry years (Figure 21). Water levels are impacted in dry years due to its small storage capacity and high local reliance of nearby communities on the lake for water supply purposes. Proctor has experienced nine drawdown events below threshold, with the duration of the events ranging from 1 day to 604 consecutive days (Figure 22). The longest drawdown started in July 1999 and ended in February 2001, and was caused by multi-year drought conditions and high local water usage. Recreational access to the reservoir is impeded at a drawdown of ten feet and has been impeded 7.9% of the time during the historical period evaluated.

WAM results for Proctor reveal that under Scenario 1, elevations are expected to equal or exceed the threshold 93% of the time. Under Scenarios 2 and 3, elevations are expected to equal or exceed the threshold 93% of the time. The public recreational access elevation for Proctor is equaled or exceeded 98.8% of the time in all Scenarios.

**Figure 21. Historical Occurrence of Threshold Elevation on Lake Proctor**

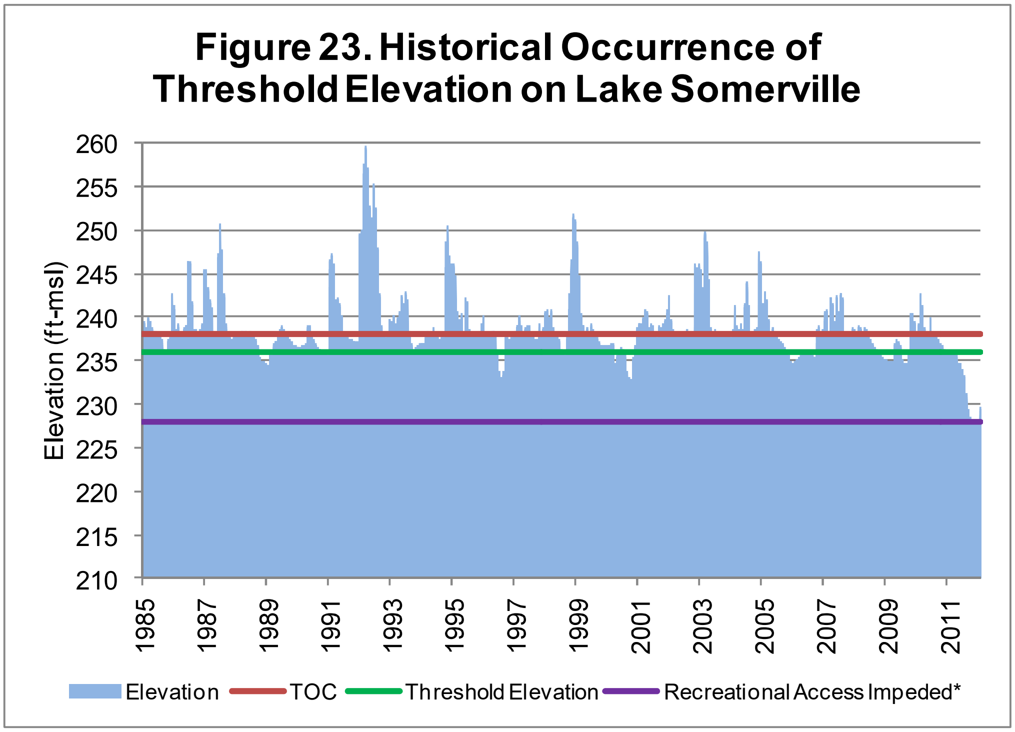


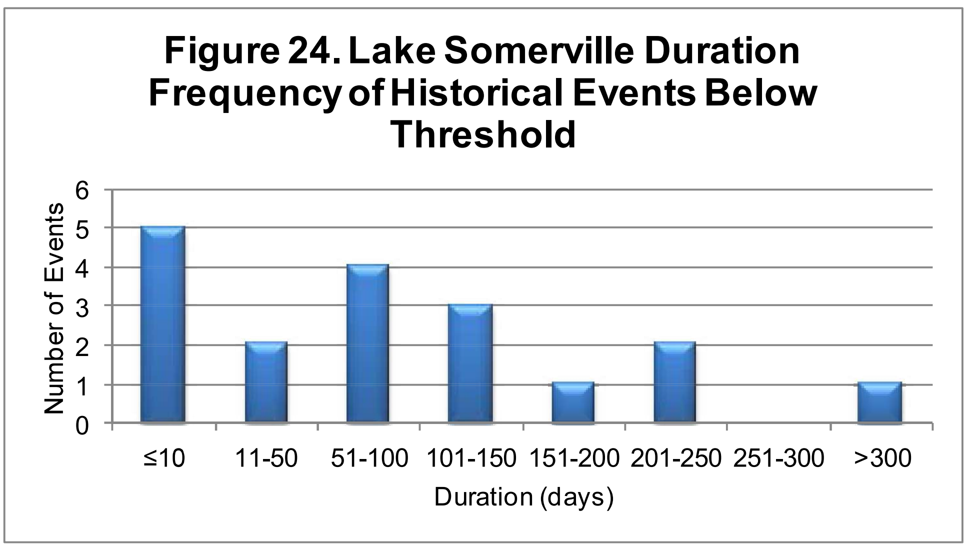



***Lake Somerville***

Somerville has experienced 18 drawdowns below the threshold, ranging from 1 day to 325 consecutive days (Figures 23 and 24). The longest drawdown lasted 325 days and started on March 11, 2011 and ended on January 22, 2012. This drawdown coincided with exceptional drought conditions which were first recorded for the Somerville area in October 2010. Precipitation amounts for the area were over 20 inches below normal. The period from October 2010 through September 2011 was the hottest, driest 12-month period in recorded history (Neilson-Gammon 2011). However, despite the exceptional drought, Somerville never fell below 38% of its storage capacity. Recreational access to the reservoir has been impeded during 1% of the historical period evaluated.

WAM results for Somerville reveal that under Scenario 1, elevations are expected to equal or exceed the threshold 84.7% of the time. Under Scenario 2, elevations are expected to equal or exceed the threshold 83.8% of the time, and under Scenario 3, 87.0% of the time. The public recreational access elevation for Somerville is equaled or exceeded 99.6% of the time in Scenario 1, and 100% of the time in Scenarios 2 and 3.

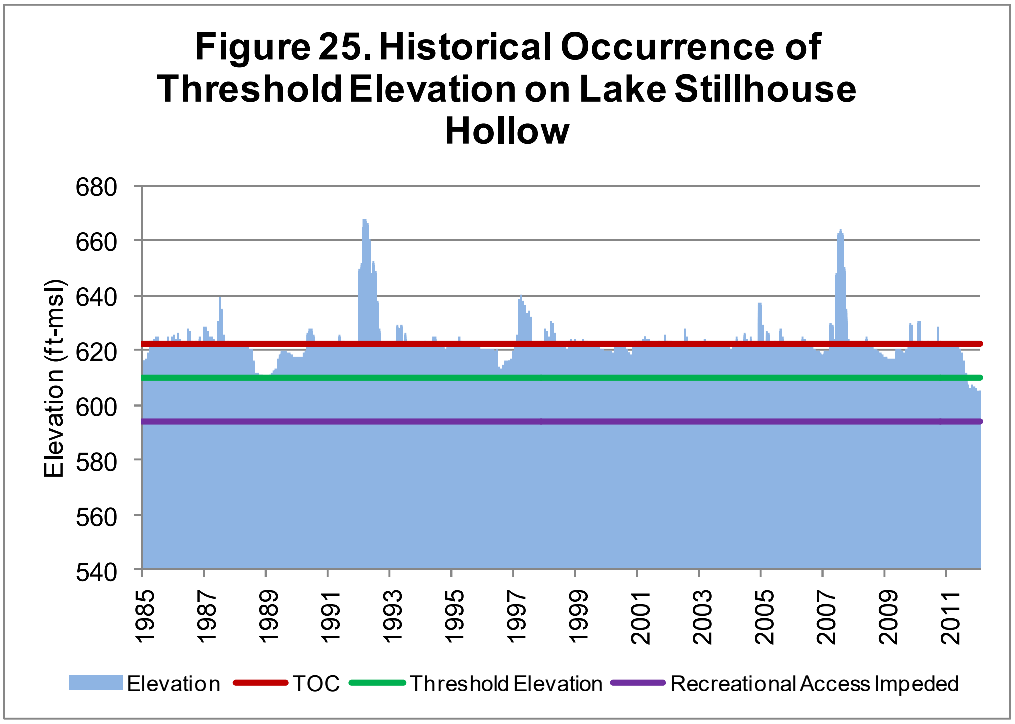



***Lake Stillhouse Hollow***

Littoral habitat declines in Stillhouse Hollow with a drawdown of 12 feet (Figure 25). A review of historical surface elevation data for Stillhouse Hollow reveals that the reservoir's surface elevation has been below the recommended threshold 2% of the time. One event of elevations below the threshold occurred in 2011-2012 and lasted 195 consecutive days. Recreational access to the reservoir has not been impeded due to low water levels.

WAM results for Stillhouse Hollow reveal that under Scenario 1, elevations are expected to equal or exceed the threshold 90.4% of the time. Under Scenario 2, elevations are expected to equal or exceed the threshold 84.4% of the time, and under Scenario 3, 85.1% of the time. The public recreational access elevation for Stillhouse Hollow is equaled or exceeded 98.1% of the time in Scenario 1, and 95.6% of the time in Scenarios 2 and 3.




***Lake Whitney***

BRA controls approximately 22% of the total conservation storage at Lake Whitney, which equates to about 2 feet of water in the conservation pool. The remaining 78% of the conservation storage in Whitney is controlled by Southwest Power Administration and utilized for hydroelectric power generation. Therefore, BRA's ability to influence habitat conditions in this lake is limited.

Whitney has experienced 24 drawdown events below the threshold between 1985 and 2011 (Figure 26). The duration of these events on Whitney ranged from 1 day to over 438 consecutive days (Figure 27). The first event in excess of one year occurred from September 2008 through October 2009 and lasted 413 days. The second event began in November 2010 and ended in January 2012 and lasted 438 days. Recreational access to the reservoir has not been impeded due to low water levels.

WAM results for Whitney reveal that under Scenario 1, elevations are expected to equal or exceed the threshold 59.5% of the time. Under Scenario 2, elevations are expected to equal or exceed the threshold 65.9% of the time, and under Scenario 3, 63.9% of the time. The public recreational access elevation for Whitney is equaled or exceeded 100% of the time in all three Scenarios.

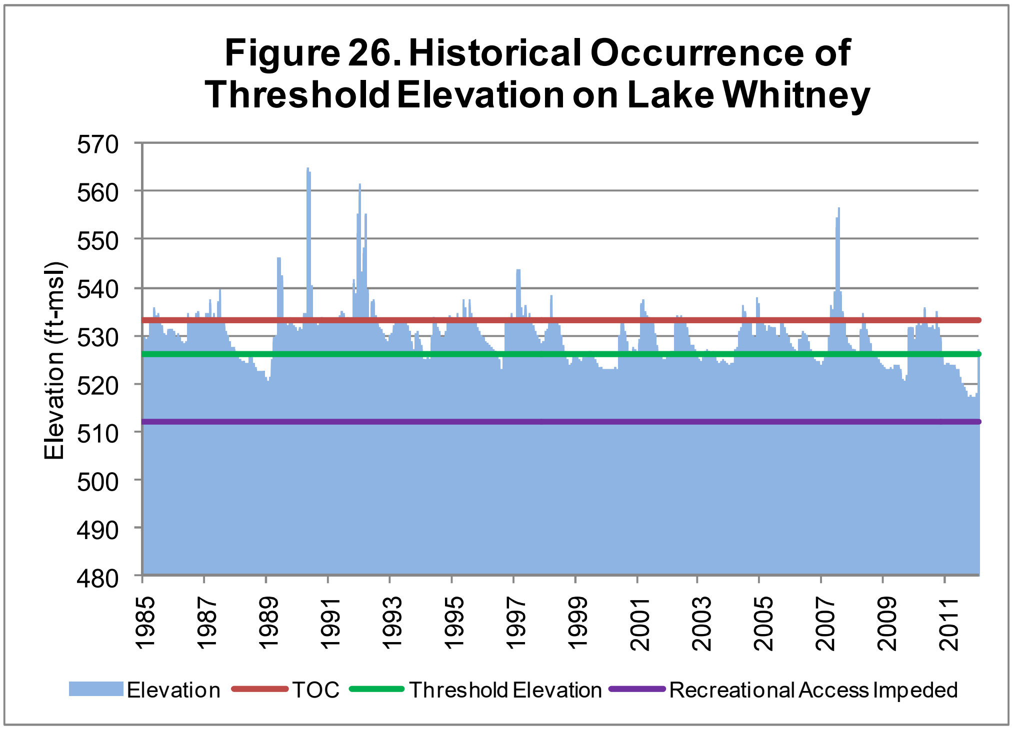
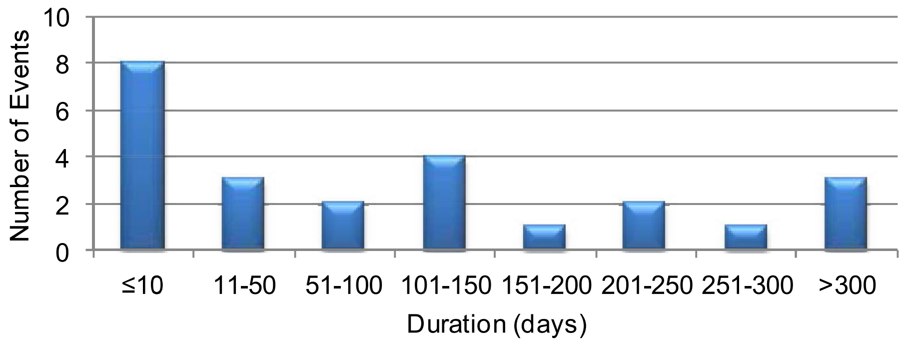


Figure 27. Lake Whitney Duration Frequency of Historical Events Below Threshold




## V. Operational Guidelines

The reservoir-specific thresholds and the general guideline are not intended to be an annual operating plan for the System reservoirs, nor will the reservoirs be intentionally drawn down to threshold elevations, unless there are extenuating circumstances. The guideline is intended to provide the BRA direction regarding reservoir usage during times of drought or other occurrences that may cause one or more of the System reservoirs to fall below the recommended thresholds for periods of time sufficient to cause impairment to littoral habitat and the associated fisheries. Additionally, the reservoir-specific thresholds and guideline will provide direction to TPWD fisheries biologists in how the BRA can be anticipated to manage reservoirs during times of drought or other causes of low reservoir elevations. They will also allow TPWD and the BRA to work collaboratively to minimize or mitigate impacts to habitat or fisheries as well as help TPWD determine if adjustments to fisheries management strategies are necessary.

In Lake Whitney, the BRA is severely limited in its ability to have any significant impact on the total capacity of the reservoir because the BRA's water rights are less than 22% of total capacity (approximately two feet of elevation when the reservoir is full). Therefore, Lake Whitney is excluded from the guideline.

The special condition in the proposed System Operation Permit stipulates that the operating guidelines relating to reservoir fisheries are subject to temporary suspension, if necessary, for water supply purposes. Across all System reservoirs, extenuating circumstances (e.g. damage to gates, maintenance on structure) may necessitate an unanticipated or intentional drawdown of an individual reservoir or restrict the BRA's ability to utilize the reservoir as part of the System for an extended period of time. Additionally, in the event of an extended, multi-year drought, the operating criteria defined below may be difficult or impossible to implement. Finally, it is important to note that these reservoir-specific thresholds and general operating guideline are just a few of many considerations with regard to BRA's operation of the System, and these guidelines cannot be considered in isolation from other factors. The BRA System reservoir operating guideline is:

> **No reservoir should be maintained continuously at an elevation below the threshold for more than three consecutive years. If the average, annual elevation falls below the threshold for three consecutive years, consideration should be given to excluding the reservoir from downstream releases until such time as the average, annual reservoir elevation meets or exceeds the threshold elevation for a duration of one year**.

## VI. Conclusions

Review of available System fisheries' performance data, the location and associated elevation of habitat features in each System reservoir, and a review of historical reservoir elevation data indicate that the System's fisheries are resilient to the effects of the drought-flood cycle in Texas. The most commonly cited limitations to fishery success in System reservoirs, as identified by TPWD, are some reservoirs' lack of habitat and inability to support aquatic vegetation, water level fluctuations, or toxic golden alga events.

The availability of littoral zone habitat varies widely across System reservoirs depending on reservoir morphology and the underlying geology. In general, littoral habitat quality declines with smaller reductions (e.g. 1 -15 ft.) in water levels, whereas decreases in littoral habitat quantity occur gradually over greater water level reductions. This variation across System reservoirs rendered infeasible a single threshold that would be the same across all reservoirs; therefore, reservoir-specific thresholds to protect littoral habitat were developed for each System reservoir.

While System reservoirs have experienced lake level fluctuations as a routine part of the drought-flood cycle, recent literature supports that this cyclic nature may be beneficial to reservoir fisheries. Some studies recommend a rotating schedule of an intentional, multi-year (3-5 years) drawdown followed by a year at total storage capacity. Historical data from System reservoirs shows that drawdowns below thresholds, where habitat availability is impacted, are infrequent and often of short duration (2 years or less). The development of the operating guideline and reservoir-specific thresholds should allow for continued success of System reservoir fisheries.

A review of historical daily elevation data does not reveal a concern for fisheries health based on littoral habitat availability. No System reservoir has been drawn down below its threshold for three consecutive years per the operating guideline above. The closest occurrence to three consecutive years was a result of an intentional drawdown that was necessary to address dam safety issues at Possum Kingdom Reservoir. A comparison of historical daily data to WAM Scenario 1 does reveal some differences, with the WAM predicting a lower frequency of time at which reservoir-specific thresholds are attained. This is a result primarily of modeling a different period of record than was used for the historical daily data analysis and the assumption that existing water rights are fully utilized within the model. The WAM results do include an analysis of the drought of record and include an estimation of what each reservoir’s elevation would have been if current water demands were in force during this time period.

Comparison of the results of WAM Scenarios 1, 2 and 3 does not identify a concern that by 2025 System reservoir attainment of threshold elevations will be significantly different from those observed under current conditions, or that fisheries health or littoral habitat will be impaired by the proposed System Operation Permit. Under Scenario 2, six System reservoirs, Aquilla, Georgetown, Granbury, Granger, Possum Kingdom, and

Stillhouse Hollow, are predicted to experience a 6% or less decline from Scenario 1 conditions in the rate of attainment of their threshold elevations. Four System reservoirs, Belton, Limestone, Proctor, and Somerville, are predicted to increase their attainment of their threshold elevations by up to 4.5% of the time, and Whitney is not predicted to experience any change in threshold attainment under Scenario 2 conditions.

Under Scenario 3, seven System reservoirs, Aquilla, Georgetown, Granbury, Granger, Possum Kingdom, Stillhouse Hollow, and Whitney, are predicted to experience up to a 8.5% or less decline from current conditions in the rate of attainment of their threshold elevations. Four System reservoirs, Belton, Limestone, Proctor, and Somerville, are predicted to increase their attainment of their thresholds by up to 5% of the time under Scenario 3 conditions.

The only observed differences between Scenarios 2 and 3 (without, and with Comanche Peak Units 3 and 4) occurred at the three mainstem reservoirs, Possum Kingdom, Granbury and Whitney. There is a predicted 4.1% change in threshold attainment at Granbury, a 2.6% change in threshold attainment at Possum Kingdom, and a 2.1% change in threshold attainment at Whitney between these scenarios.

Review of recreational access elevations using WAM Scenarios 2 and 3 indicates that existing public boat ramps at most System reservoirs should be adequate to provide recreational access to the reservoirs through 2025. All the reservoirs' public boat ramp facilities, with the exception of Limestone, are predicted to provide public access at least 95% of the time. Limestone is predicted to equal or exceed its recreational access elevation approximately 89% of the time by 2025.

The identification of the reservoir-specific thresholds at which littoral habitat becomes reduced, and the duration for which it is reduced, are relevant to the decision making process within System reservoir operations. The operating guideline and reservoir-specific thresholds are designed to shield System reservoirs from long-term drawdowns that cause littoral habitat loss and potentially the loss of multiple, consecutive year classes of fishes. In the event that the threshold cannot be maintained at a System reservoir for the time period specified in the guideline, the threshold will be useful in alerting the BRA to remove the reservoir from downstream releases, if possible, to prevent further reduction in water levels. If the thresholds cannot be maintained per the guideline across multiple System reservoirs, the thresholds will be useful for identifying and prioritizing System reservoir use.

The proposed System Operation Permit does not appear to have an overriding negative impact on projected reservoir elevations. However, if future conditions do change to a degree where the thresholds and guideline are not being attained on a routine basis for a given reservoir, this will serve as an indicator to TPWD and BRA that either fisheries management strategies, or the guideline and threshold, may need to be adjusted for that reservoir to mitigate the negative effects that reduced water levels may have on the fisheries of that reservoir.

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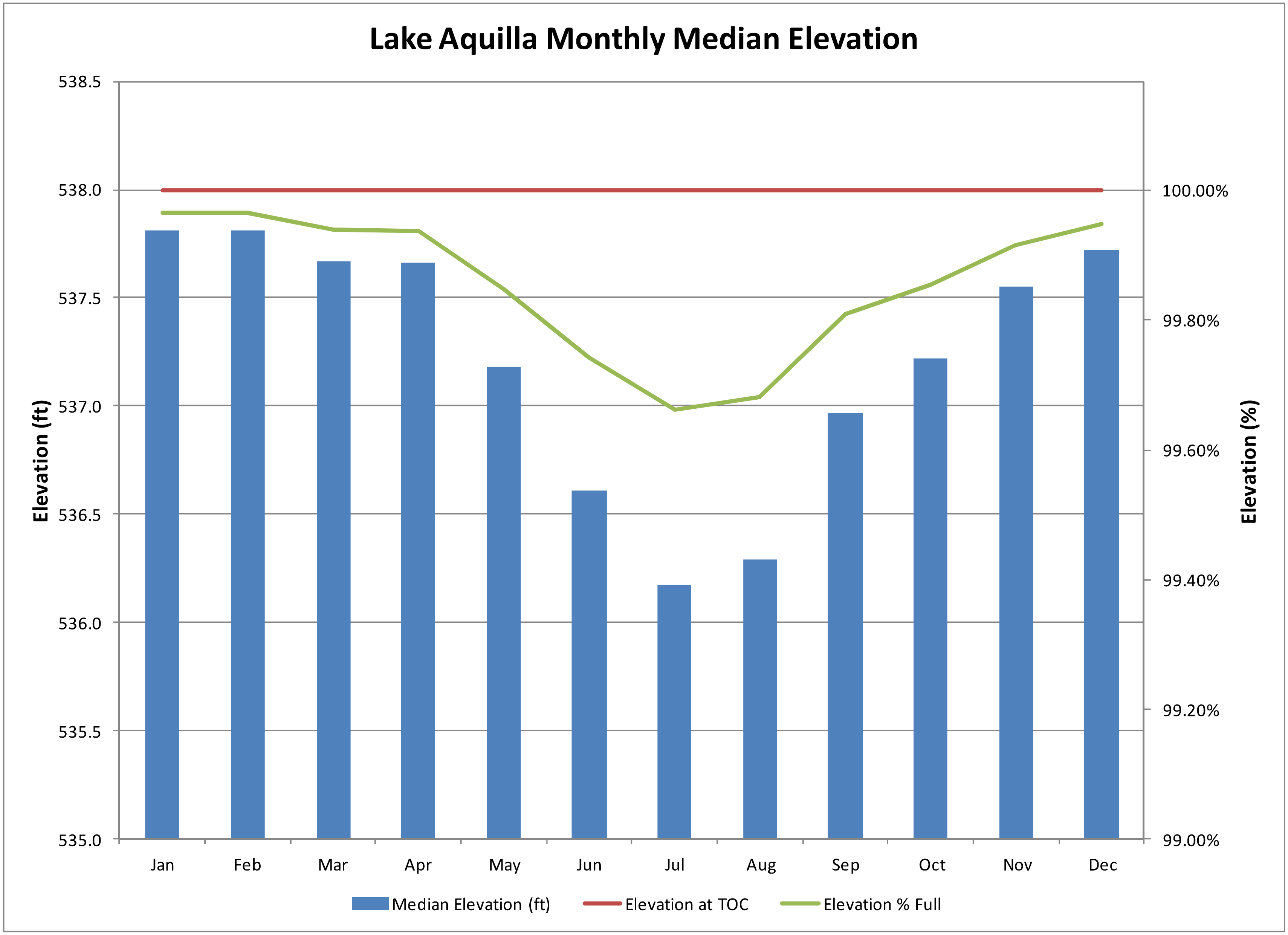
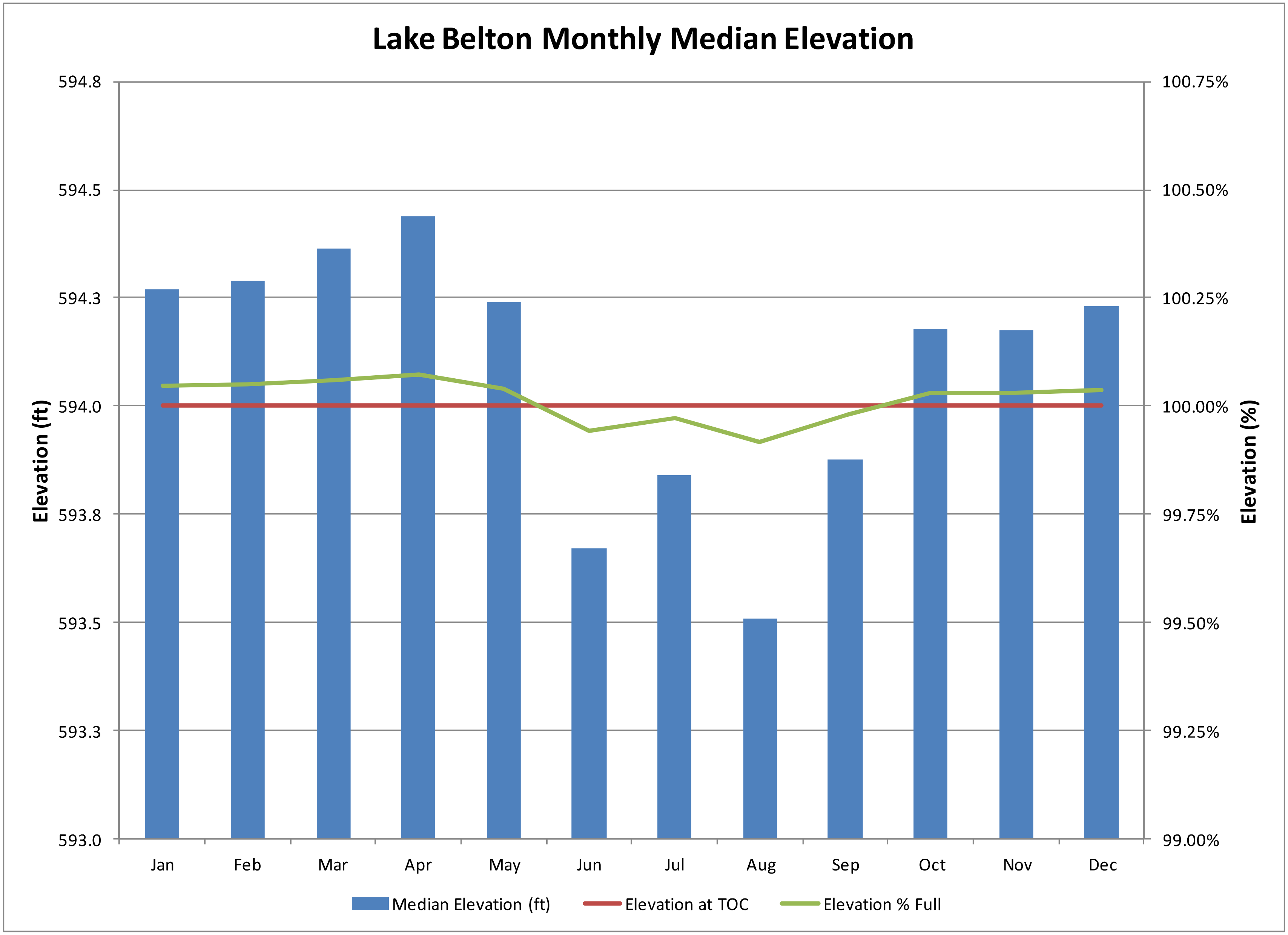
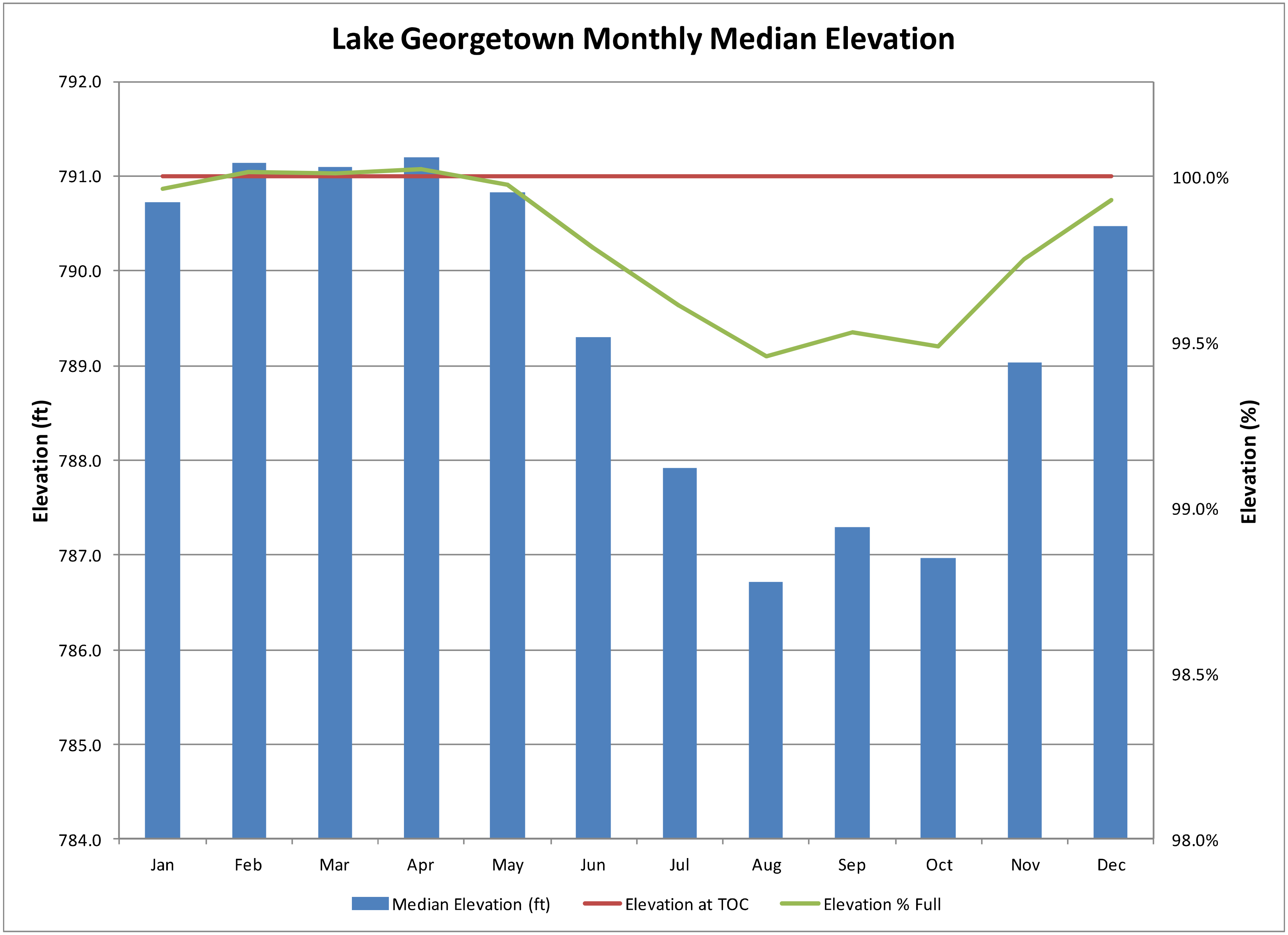
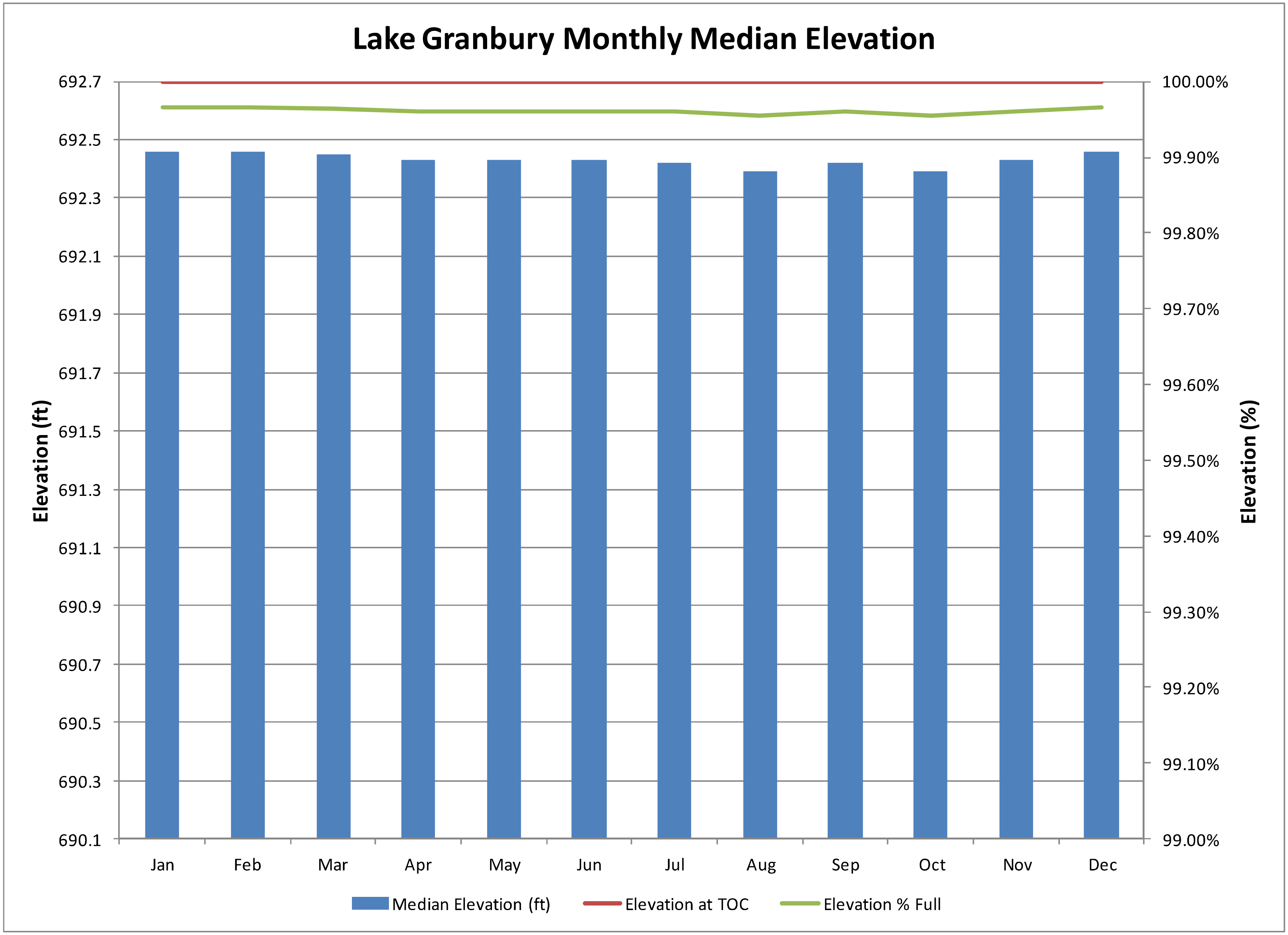
# Appendix A
# Monthly Median Elevation by Reservoir

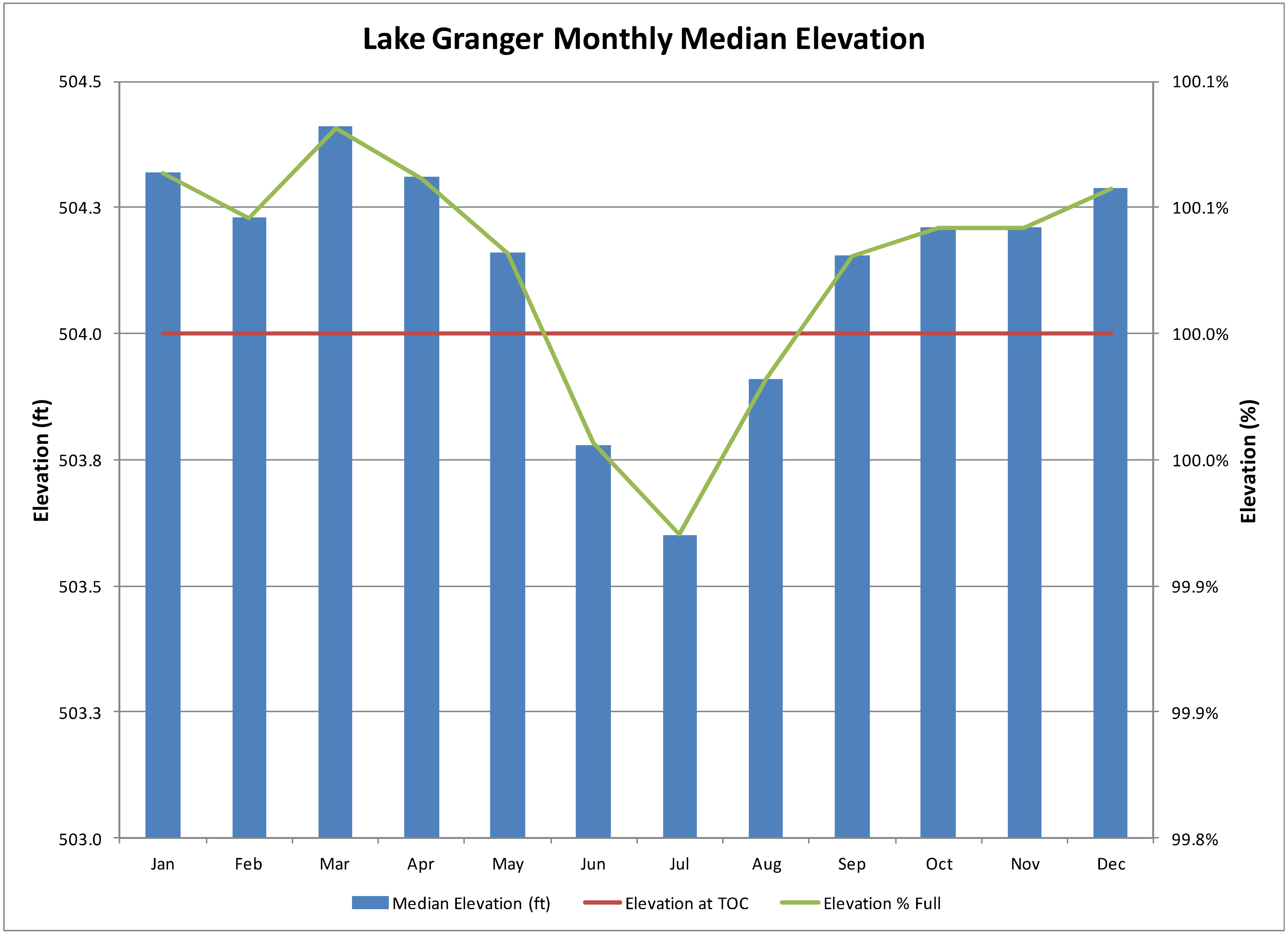

Lake Aquilla Monthly Median Elevation
538.5
538.0
537.5
537.0
536.5
536.0
535.5
535.0
Elevation (ft)
100.00%
99.80%
99.60%
99.40%
99.20%
99.00%
Elevation (%)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Median Elevation (ft)
Elevation at TOC
Elevation % Full

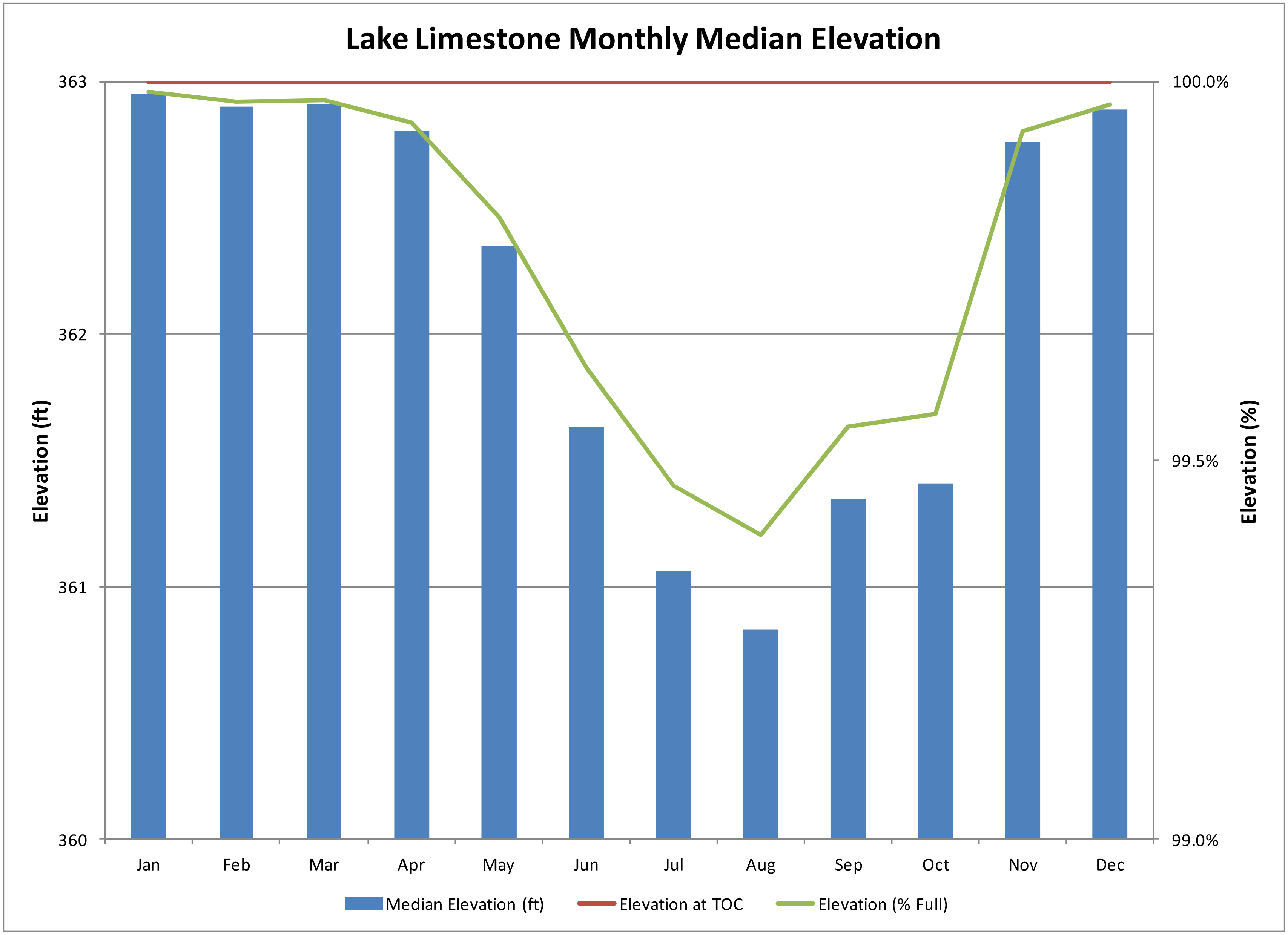

Lake Belton Monthly Median Elevation
594.8
594.5
594.3
594.0
593.8
593.5
593.3
593.0
Elevation (ft)
100.75%
100.50%
100.25%
100.00%
99.75%
99.50%
99.25%
99.00%
Elevation (%)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Median Elevation (ft)
Elevation at TOC
Elevation % Full


Lake Georgetown Monthly Median Elevation
Elevation (ft)
792.0
791.0
790.0
789.0
788.0
787.0
786.0
785.0
784.0
Elevation (%)
100.0%
99.5%
99.0%
98.5%
98.0%
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Median Elevation (ft)
Elevation at TOC
Elevation % Full

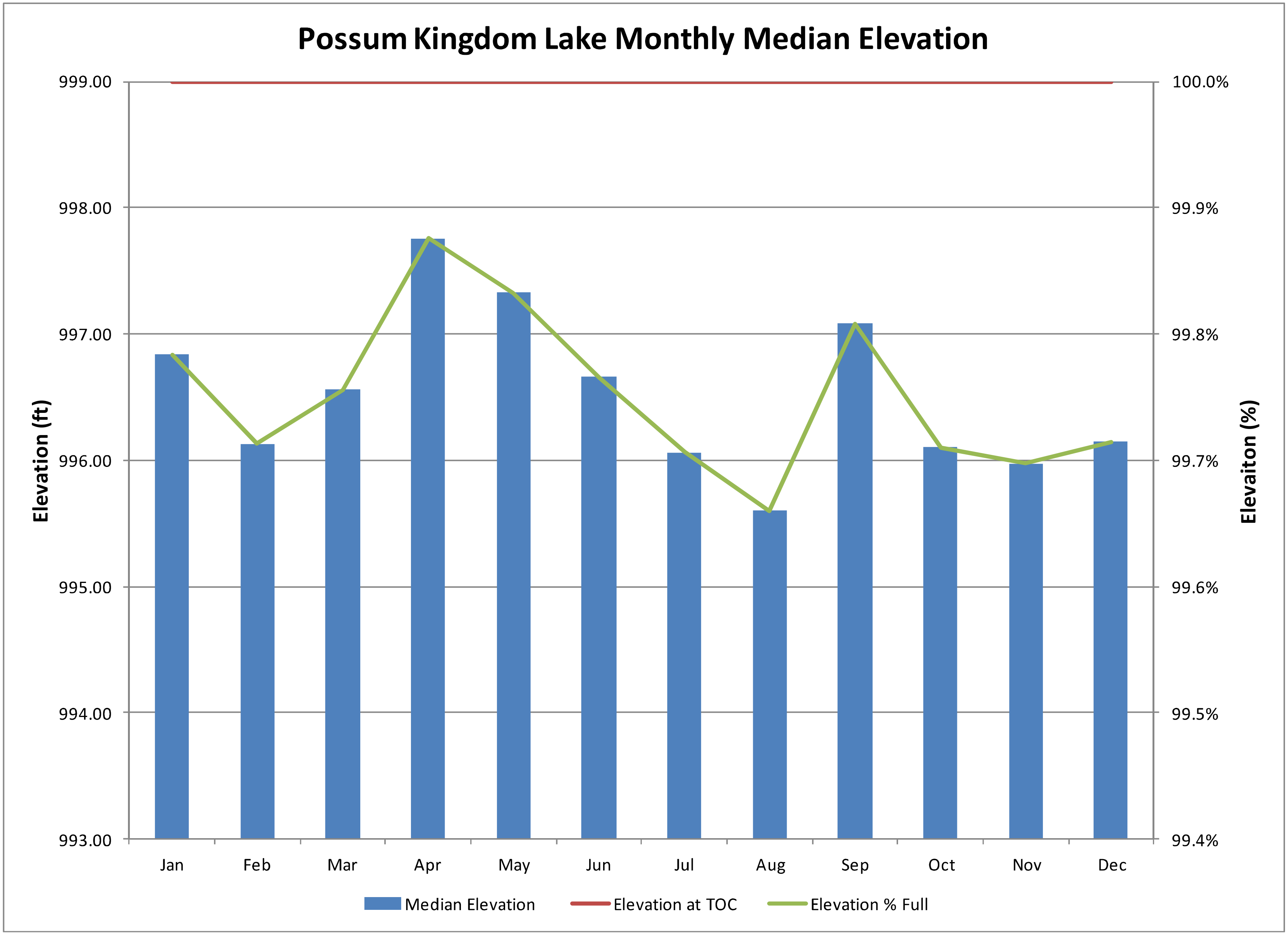


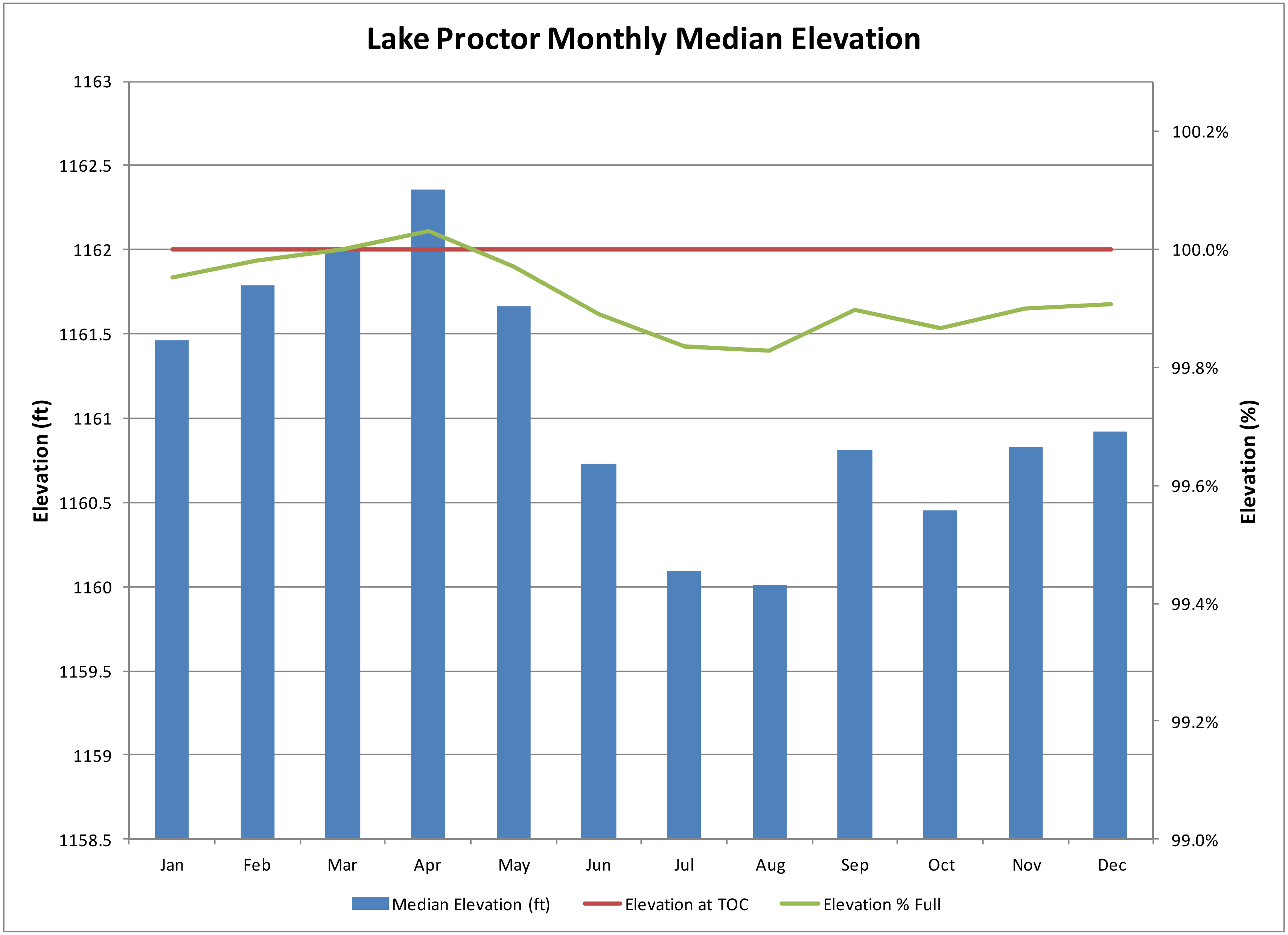
Lake Granbury Monthly Median Elevation
Elevation (ft)
692.7
692.5
692.3
692.1
691.9
691.7
691.5
691.3
691.1
690.9
690.7
690.5
690.3
690.1
Elevation (%)
100.00%
99.90%
99.80%
99.70%
99.60%
99.50%
99.40%
99.30%
99.20%
99.10%
99.00%
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Median Elevation (ft)
Elevation at TOC
Elevation % Full

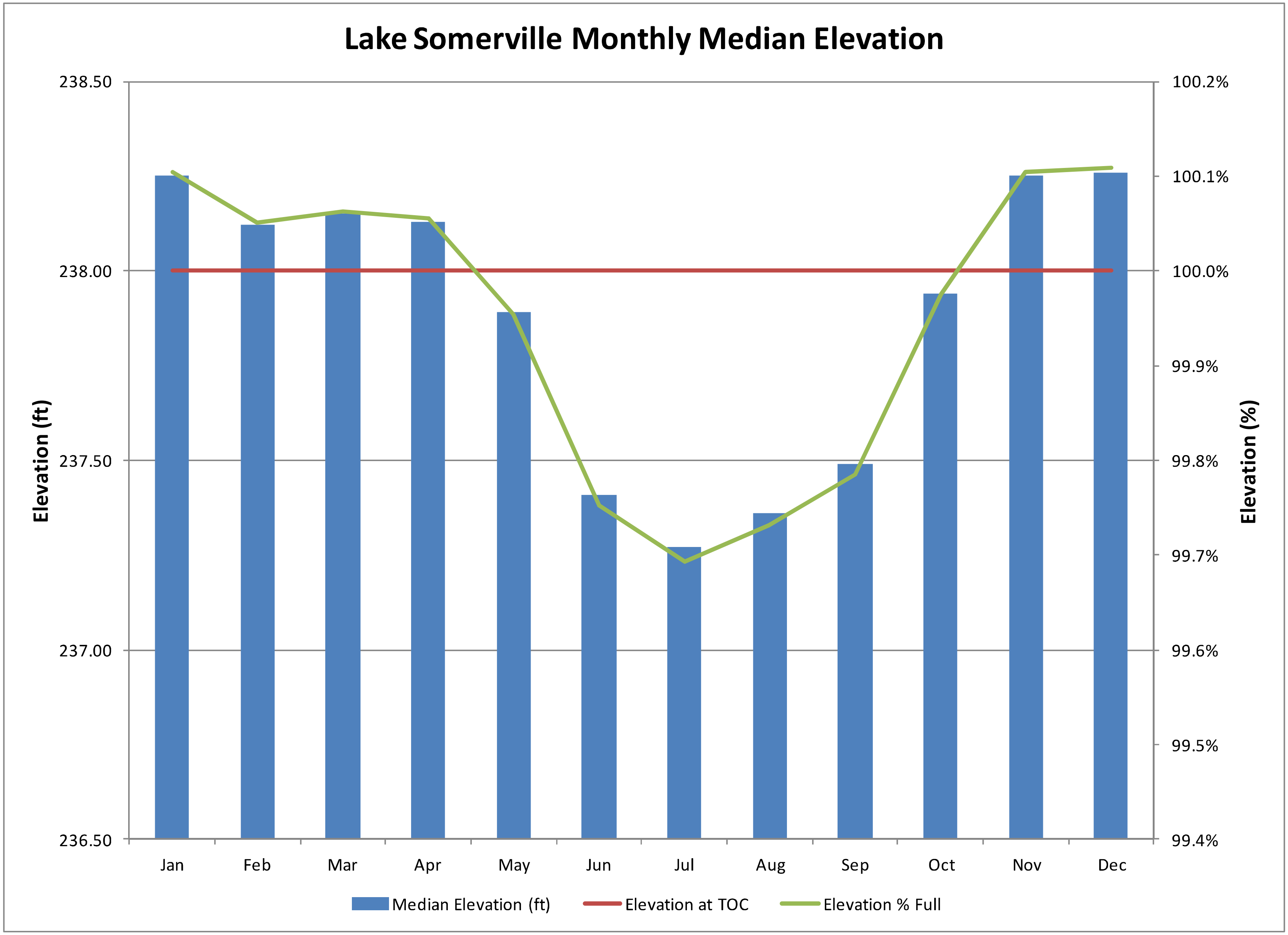

Lake Granger Monthly Median Elevation
Elevation (ft)
504.5
504.3
504.0
503.8
503.5
503.3
503.0
Elevation (%)
100.1%
100.1%
100.0%
100.0%
99.9%
99.9%
99.8%
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Median Elevation (ft)
Elevation at TOC
Elevation % Full

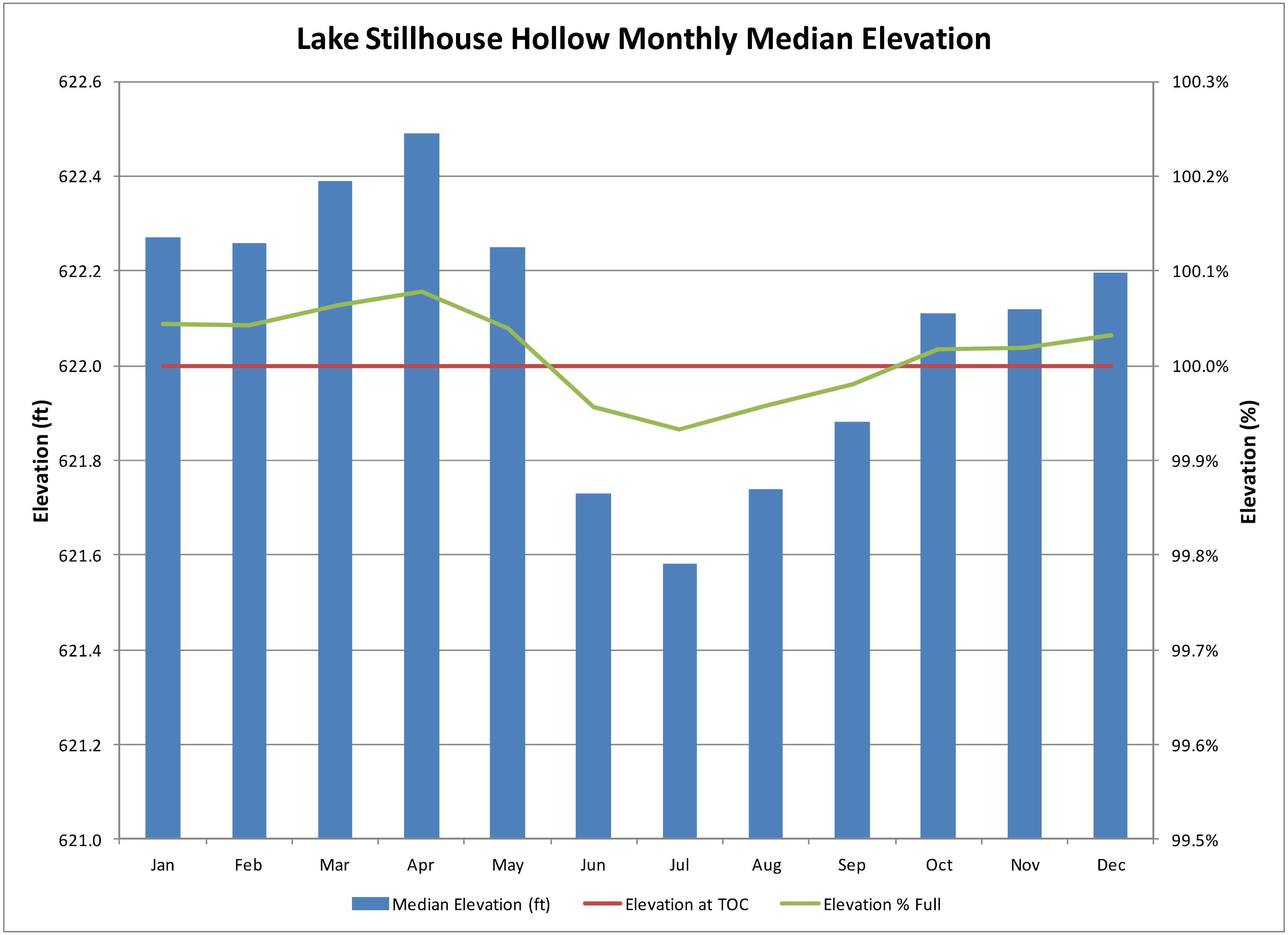


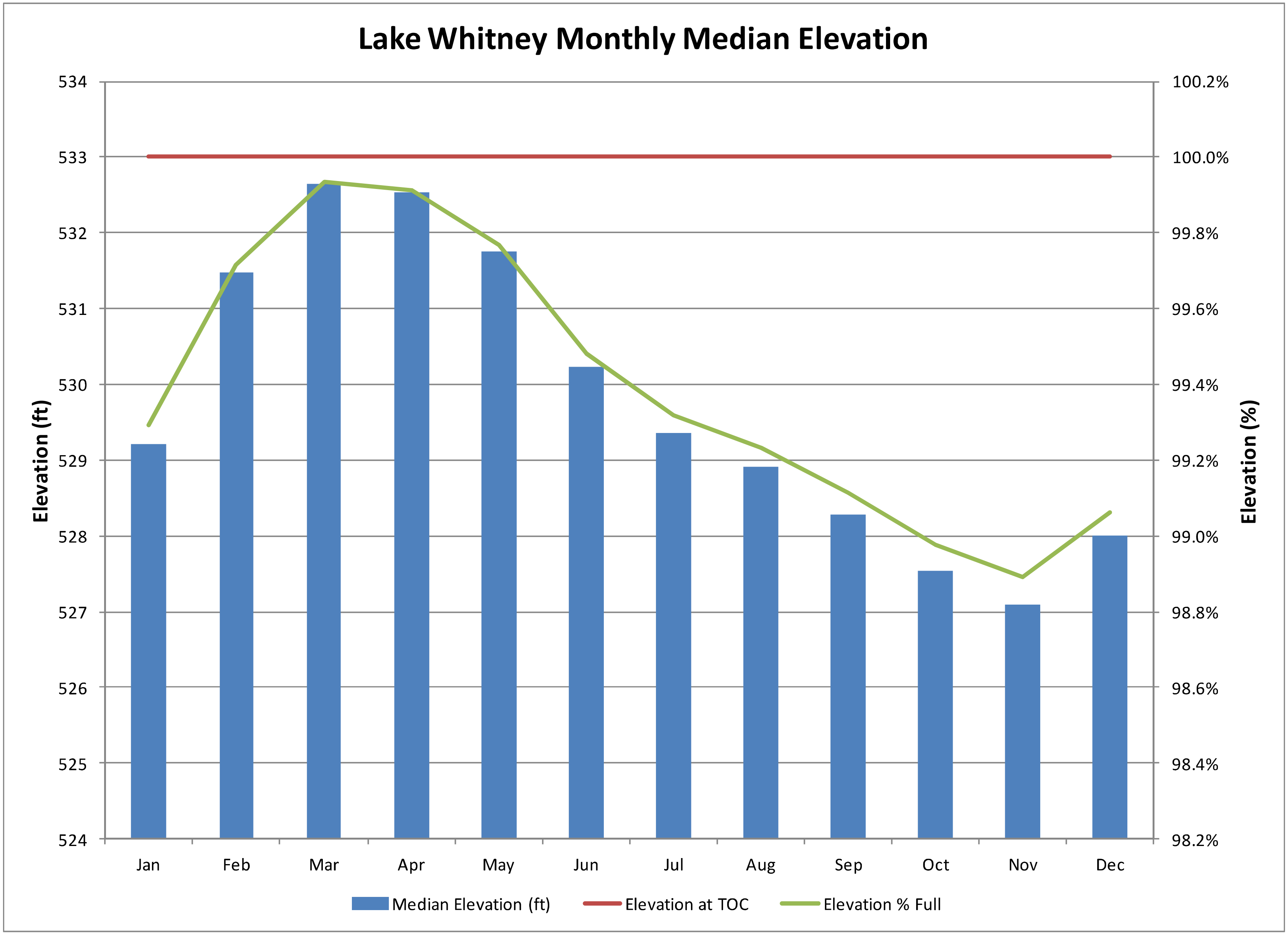
Lake Limestone Monthly Median Elevation
363
362
361
360
Elevation (ft)
100.0%
99.5%
99.0%
Elevation (%)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Median Elevation (ft)
Elevation at TOC
Elevation (% Full)


Possum Kingdom Lake Monthly Median Elevation
Elevation (ft)
Elevaiton (%)
999.00
998.00
997.00
996.00
995.00
994.00
993.00
100.0%
99.9%
99.8%
99.7%
99.6%
99.5%
99.4%
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Median Elevation
Elevation at TOC
Elevation % Full


Lake Proctor Monthly Median Elevation
Elevation (ft)
1163
1162.5
1162
1161.5
1161
1160.5
1160
1159.5
1159
1158.5
Elevation (%)
100.2%
100.0%
99.8%
99.6%
99.4%
99.2%
99.0%
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Median Elevation (ft)
Elevation at TOC
Elevation % Full


Lake Somerville Monthly Median Elevation
Elevation (ft)
238.50
238.00
237.50
237.00
236.50
Elevation (%)
100.2%
100.1%
100.0%
99.9%
99.8%
99.7%
99.6%
99.5%
99.4%
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Median Elevation (ft)
Elevation at TOC
Elevation % Full


Lake Stillhouse Hollow Monthly Median Elevation
Elevation (ft)
Elevation (%)
622.6
622.4
622.2
622.0
621.8
621.6
621.4
621.2
621.0
100.3%
100.2%
100.1%
100.0%
99.9%
99.8%
99.7%
99.6%
99.5%
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Median Elevation (ft)
Elevation at TOC
Elevation % Full


Lake Whitney Monthly Median Elevation
534
533
532
531
530
529
528
527
526
525
524
Elevation (ft)
100.2%
100.0%
99.8%
99.6%
99.4%
99.2%
99.0%
98.8%
98.6%
98.4%
98.2%
Elevation (%)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Median Elevation (ft)
Elevation at TOC
Elevation % Full

# Appendix B
# Littoral Habitat Availability Charts by Reservoir
Provided by the Texas Parks and Wildlife Department

## Lake Aquilla

Figure 1. Elevation specific littoral zone (< 4 ft. water depth) coverage in Lake Aquilla, Texas for upper, middle, and lower reservoir reaches and all reaches combined.

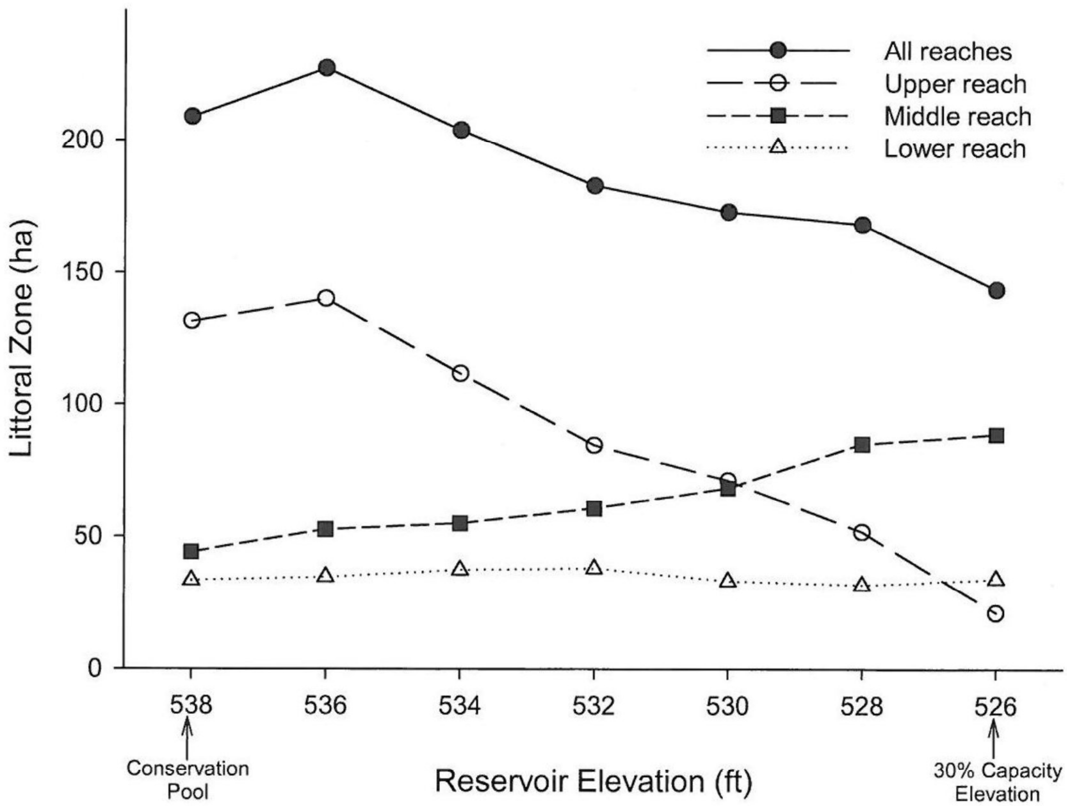


Figure 2. Elevation specific littoral zone (< 4 ft. water depth) coarse substrate availability in Lake Aquilla, Texas.

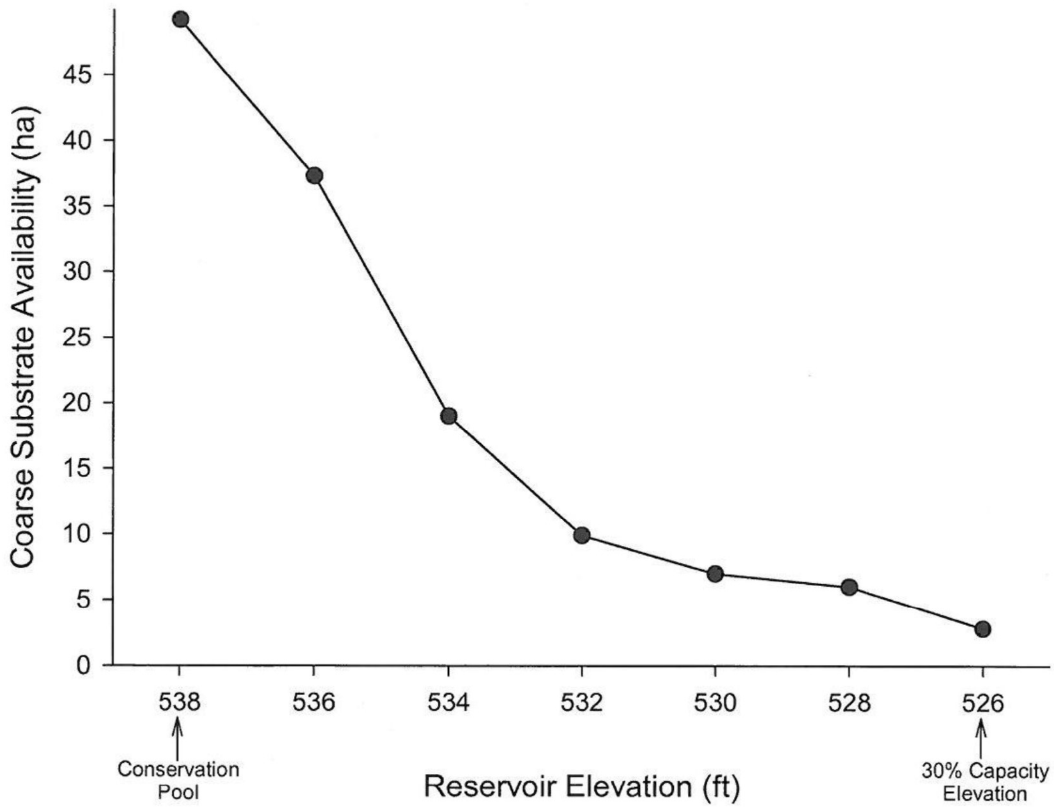


Figure 3. Elevation specific littoral zone (< 4 ft. water depth) woody and vegetative habitat availability in Lake Aquilla, Texas. Woody habitat was defined as one inundated standing tree, downed tree, or brush pile attractor.

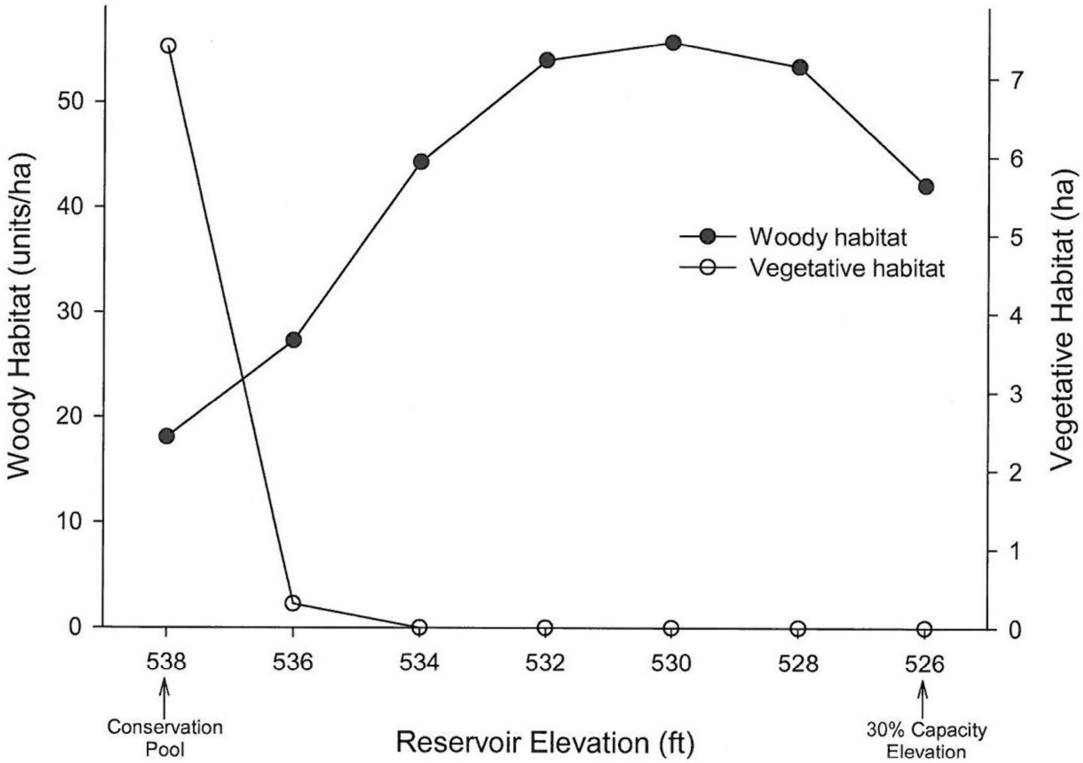
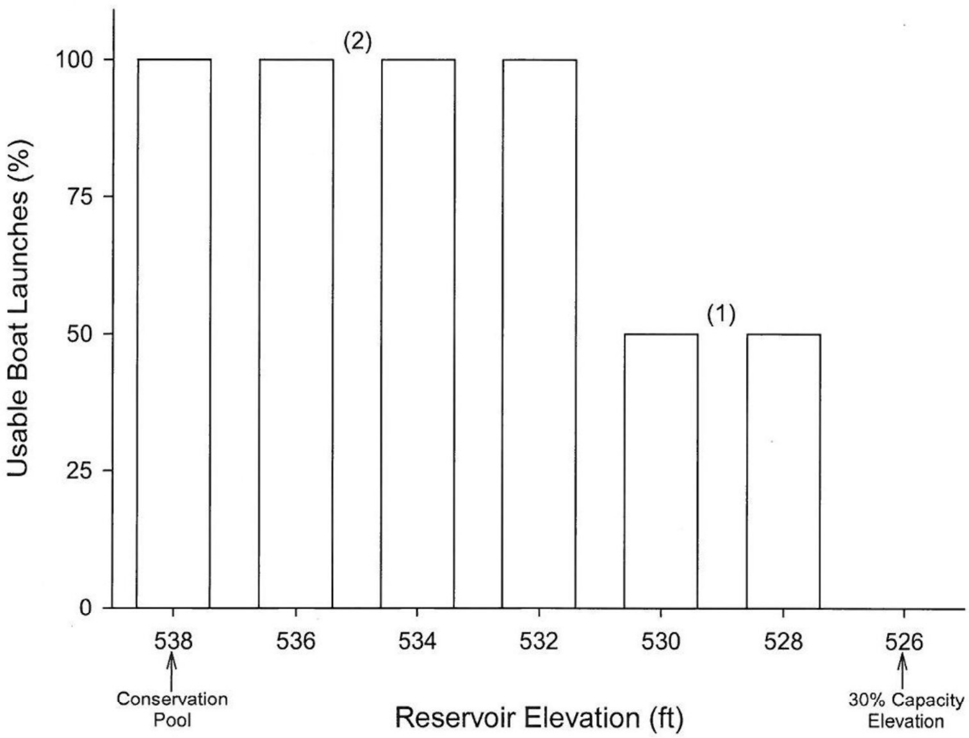


Figure 4. Elevation specific boat accessibility in Lake Aquilla, Texas. The number of usable boat launches provided above each bar.



## Lake Belton

Figure 1. Elevation specific littoral zone (< 8 ft. water depth) coverage in Lake Belton, Texas, for upper, middle, and lower reservoir reaches and all reaches combined.

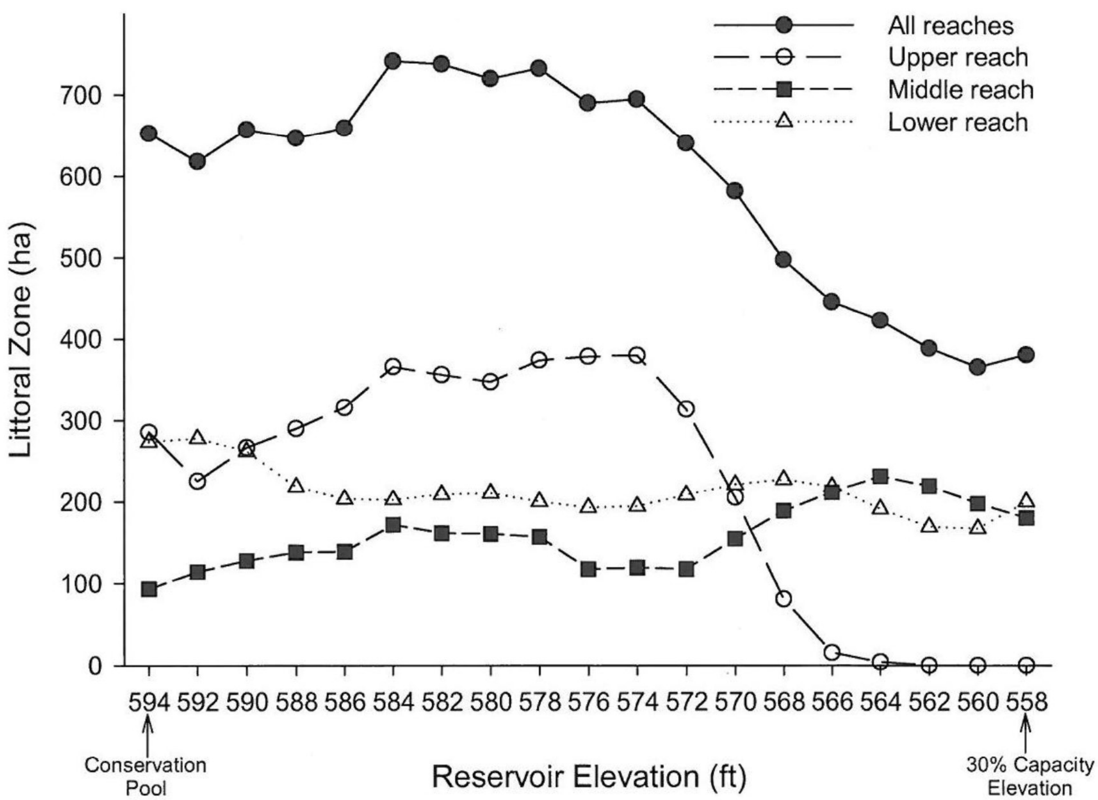


Figure 2. Elevation specific littoral zone (< 8 ft. water depth) coarse substrate availability in Lake Belton, Texas.

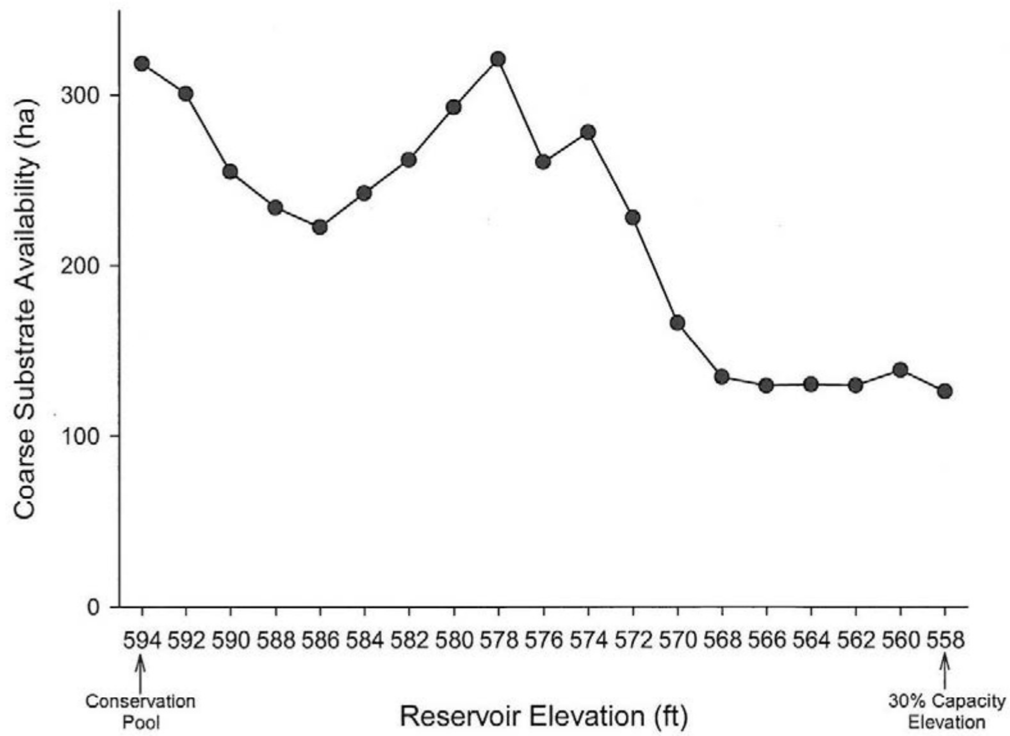


Figure 3. Elevation specific littoral zone (< 8 ft. water depth) woody habitat availability in Lake Belton, Texas. Woody habitat was defined as one inundated standing tree, downed tree, or brush pile attractor.

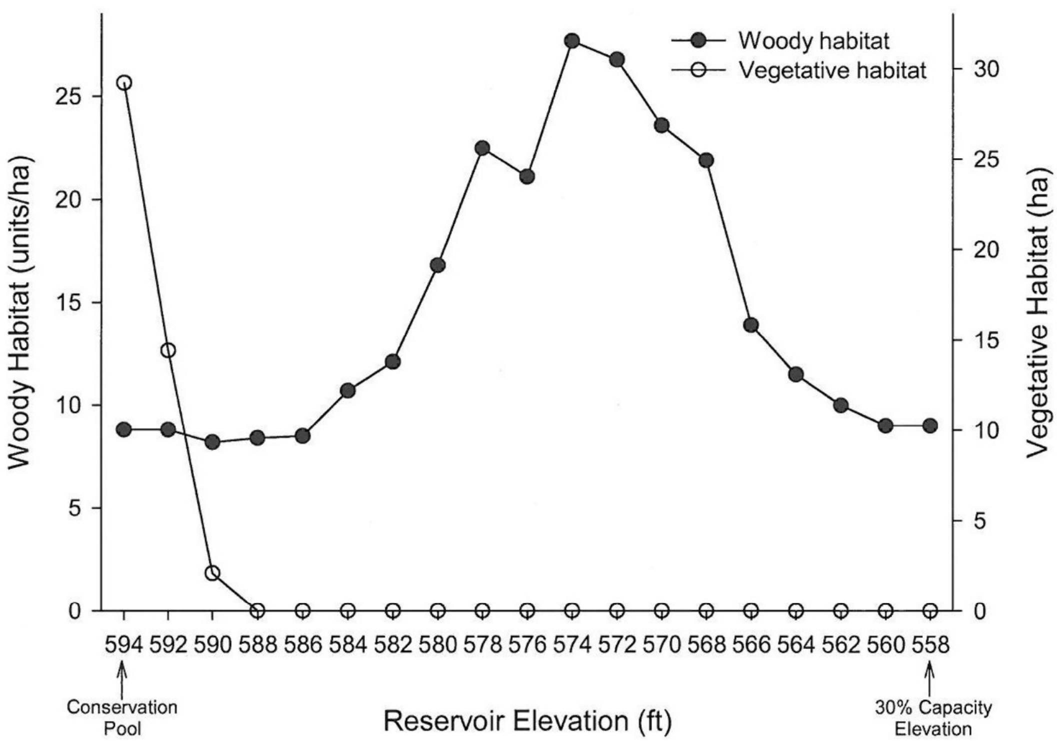
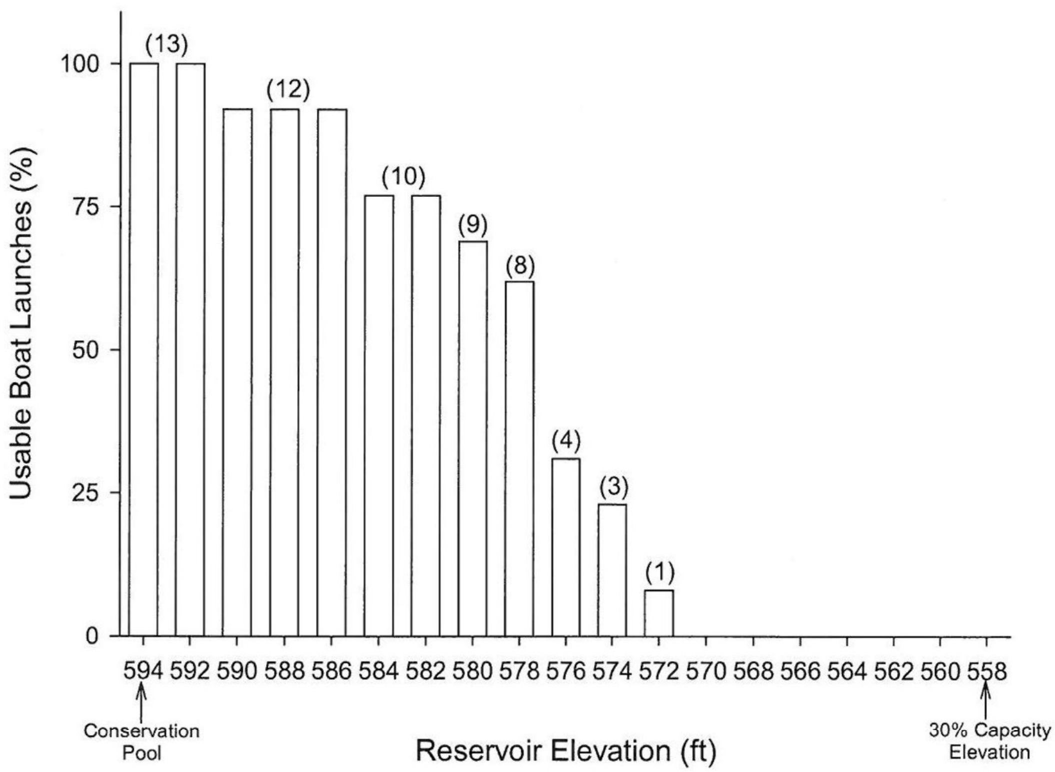


Figure 4. Elevation specific boat accessibility in Lake Belton, Texas. The number of usable boat launches provided above each bar.



## Lake Georgetown

Figure 1. Elevation specific littoral zone (< 6 ft. water depth) coverage in Lake Georgetown, Texas, for upper, middle, and lower reservoir reaches and all reaches combined.

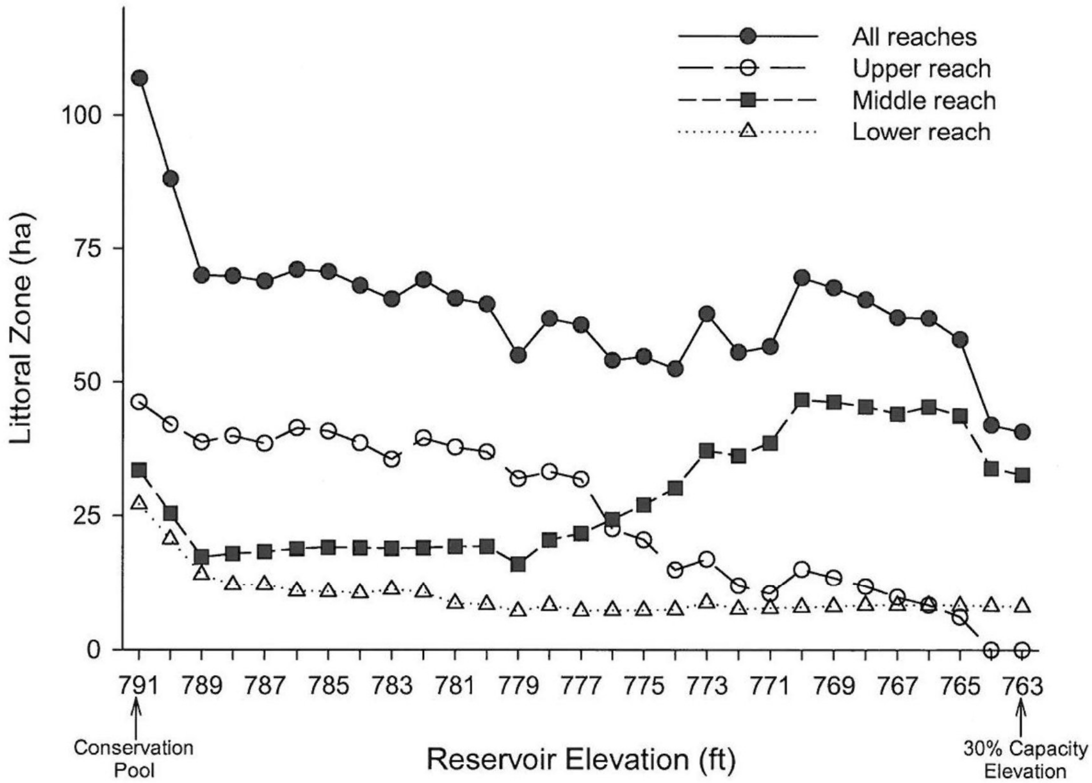


Figure 2. Elevation specific littoral zone (< 6 ft. water depth) coarse substrate availability in Lake Georgetown, Texas.

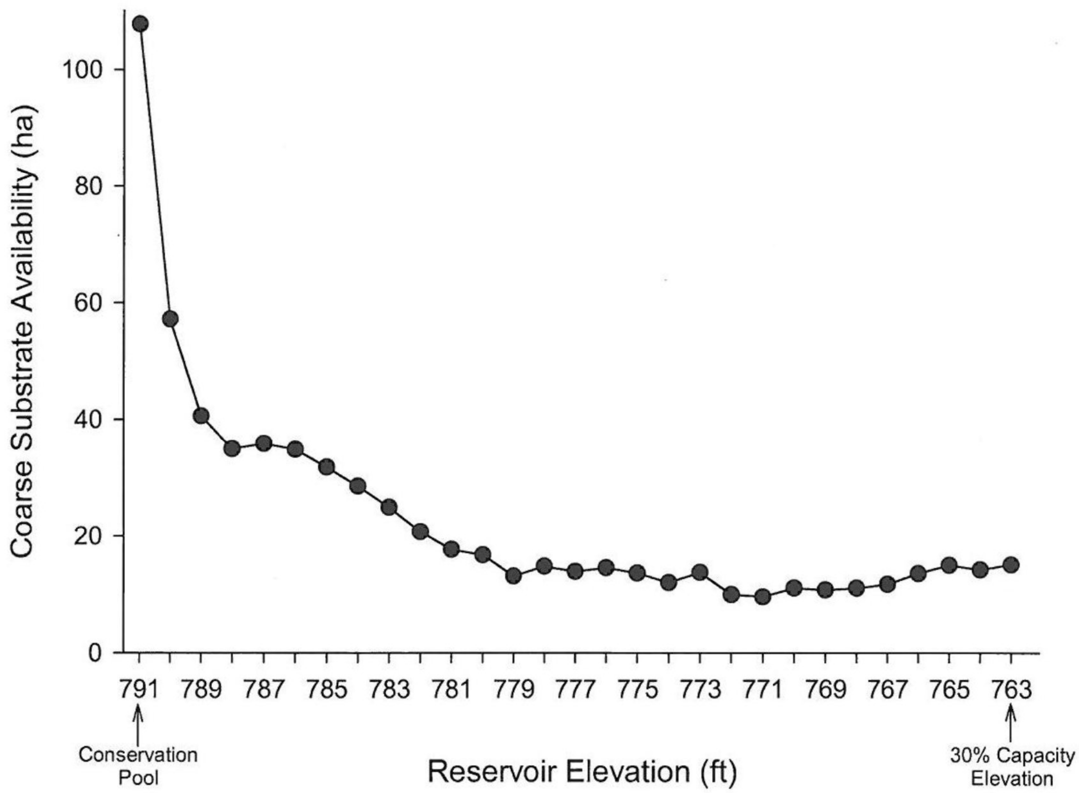


Figure 3. Elevation specific littoral zone (< 6 ft. water depth) woody habitat availability in Lake Georgetown, Texas. Woody habitat was defined as one inundated standing tree, downed tree, or brush pile attractor.

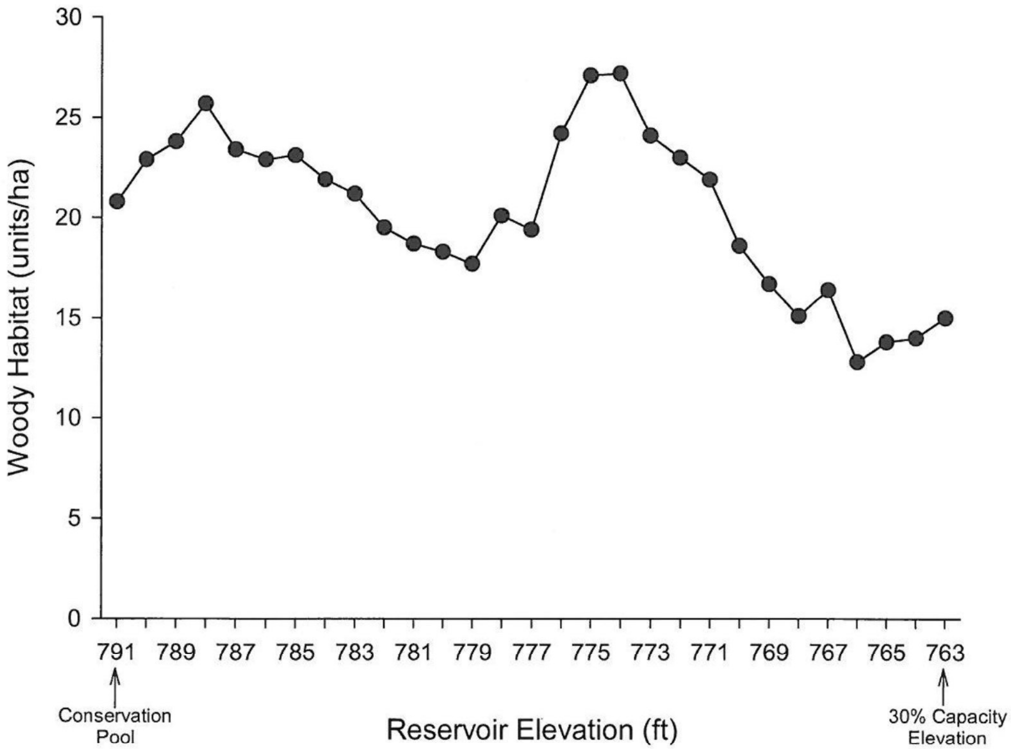
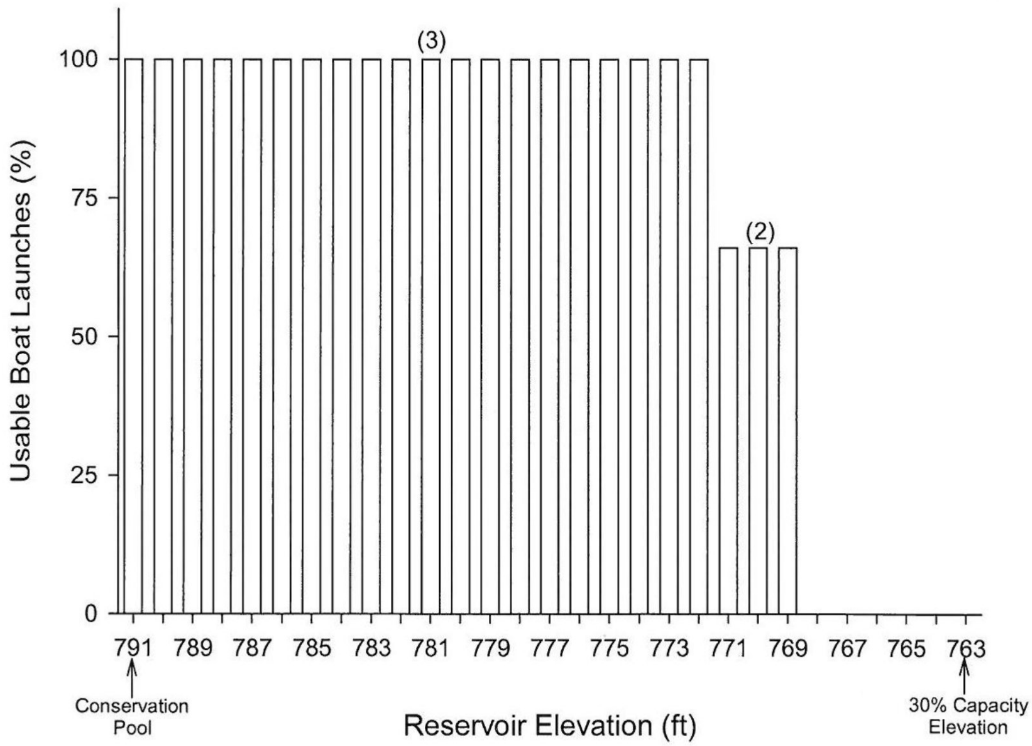


Figure 4. Elevation specific boat accessibility in Lake Georgetown, Texas. The number of usable boat launches provided above each bar.



## Lake Granbury

Figure 1. Elevation specific littoral zone (< 6 ft. water depth) coverage in Lake Granbury, Texas, for upper, middle, and lower reservoir reaches and all reaches combined.

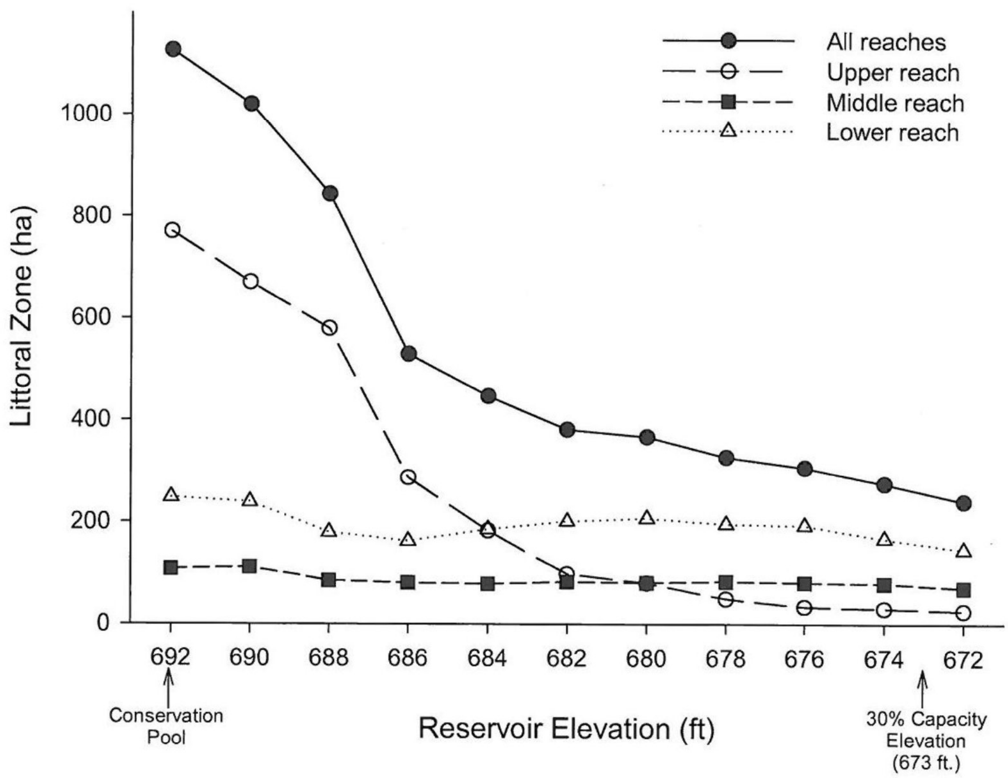


Figure 2. Elevation specific littoral zone (< 6 ft. water depth) coarse substrate availability in Lake Granbury, Texas.

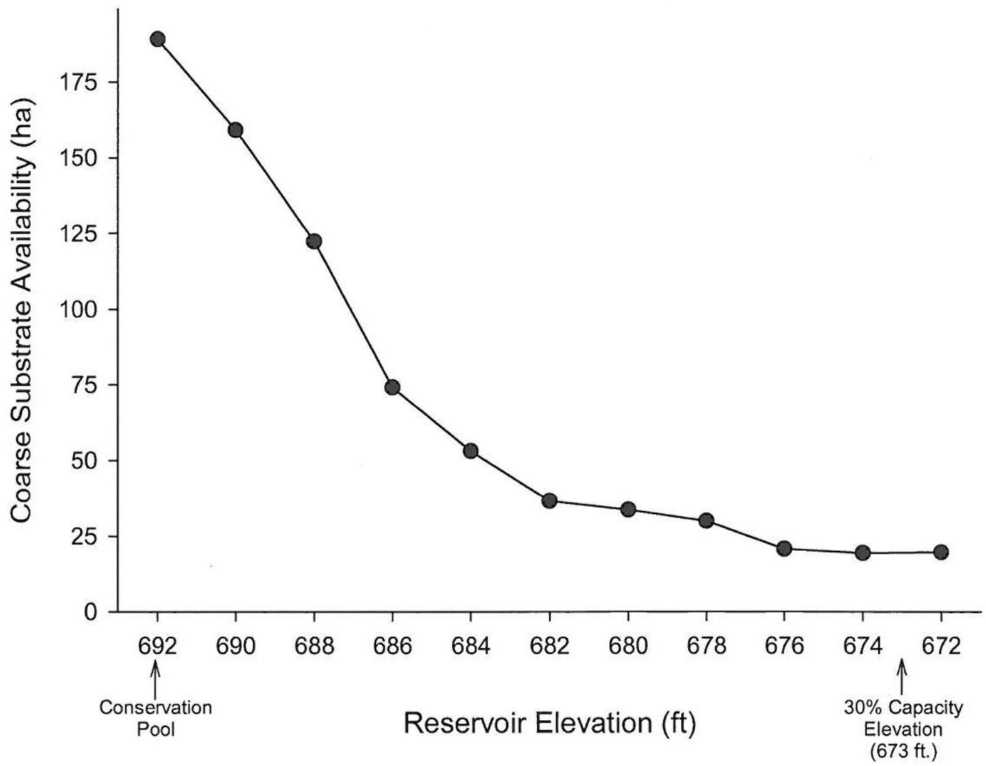


Figure 3. Elevation specific littoral zone (< 6 ft. water depth) woody and vegetative habitat availability in Lake Granbury, Texas. Woody habitat was defined as one inundated standing tree, downed tree, or brush pile attractor.

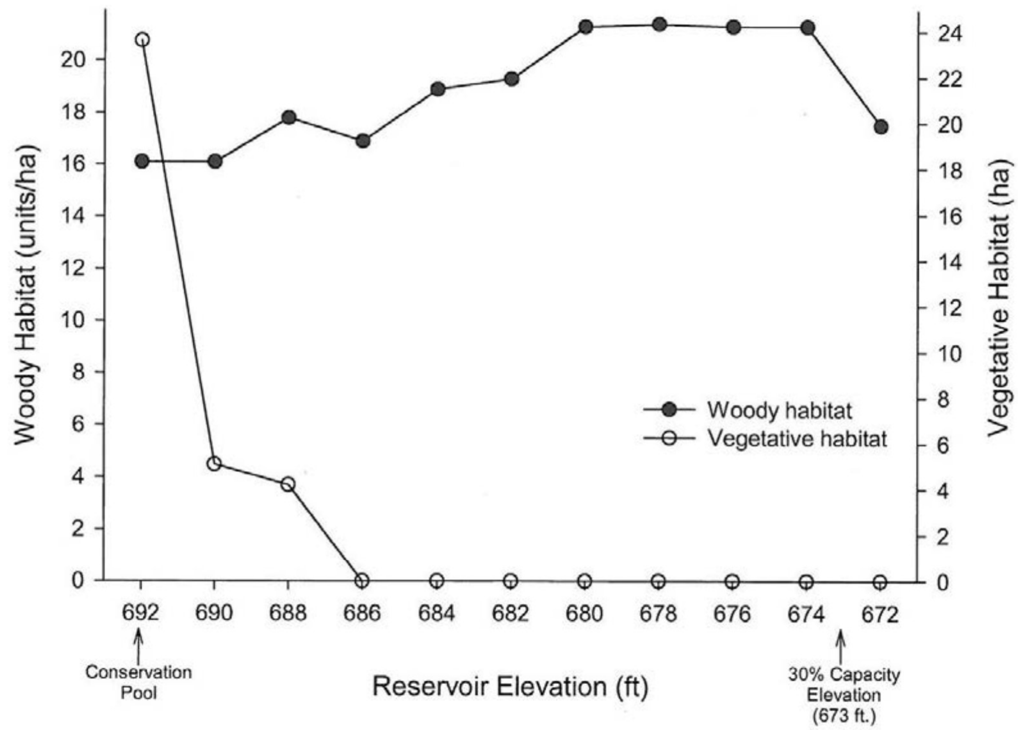
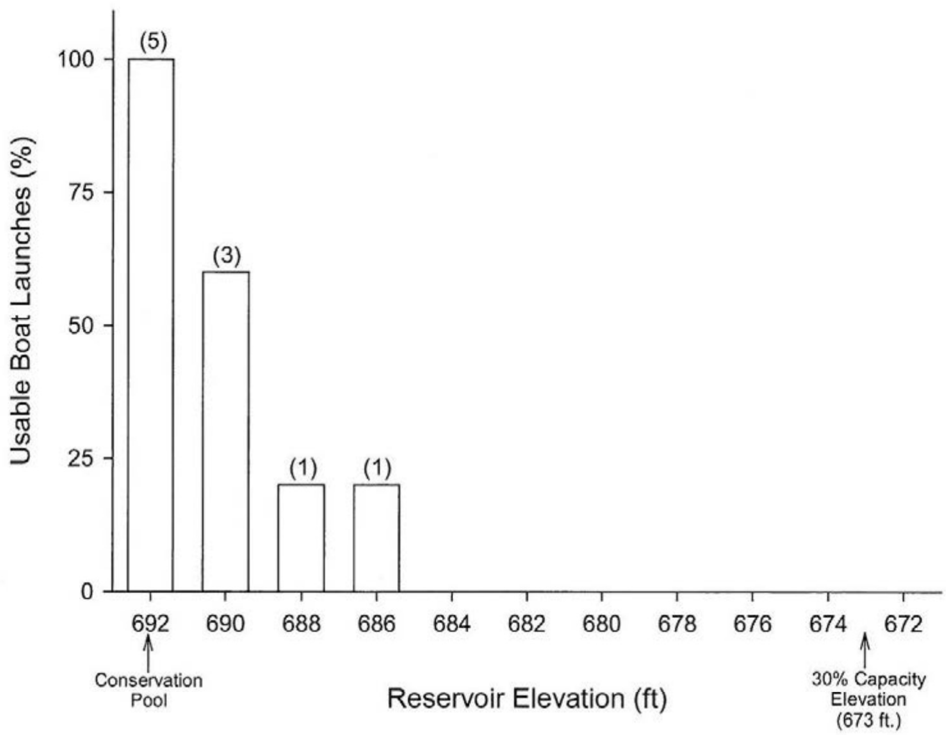


Figure 4. Elevation specific boat accessibility in Lake Granbury, Texas. The number of usable boat launches provided above each bar.



## Lake Granger

Figure 1. Elevation specific littoral zone (< 2 ft. water depth) coverage in Granger Lake, Texas for upper, middle, and lower reservoir reaches and all reaches combined.

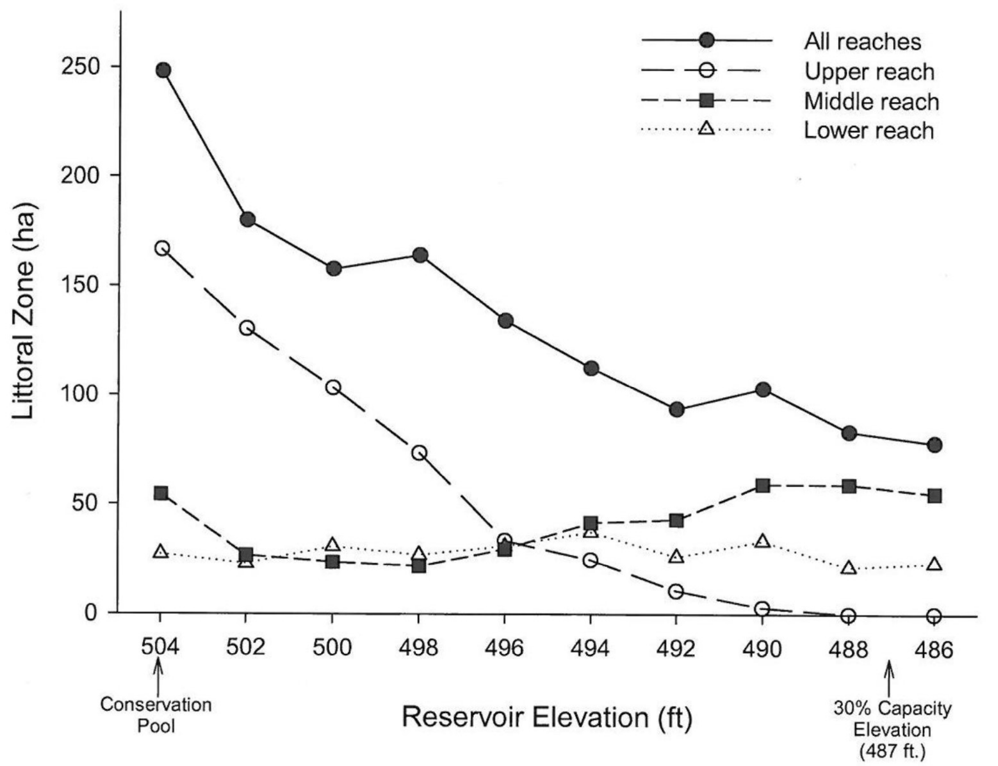


Figure 2. Elevation specific littoral zone (< 2 ft. water depth) coarse substrate availability in Granger Lake, Texas.

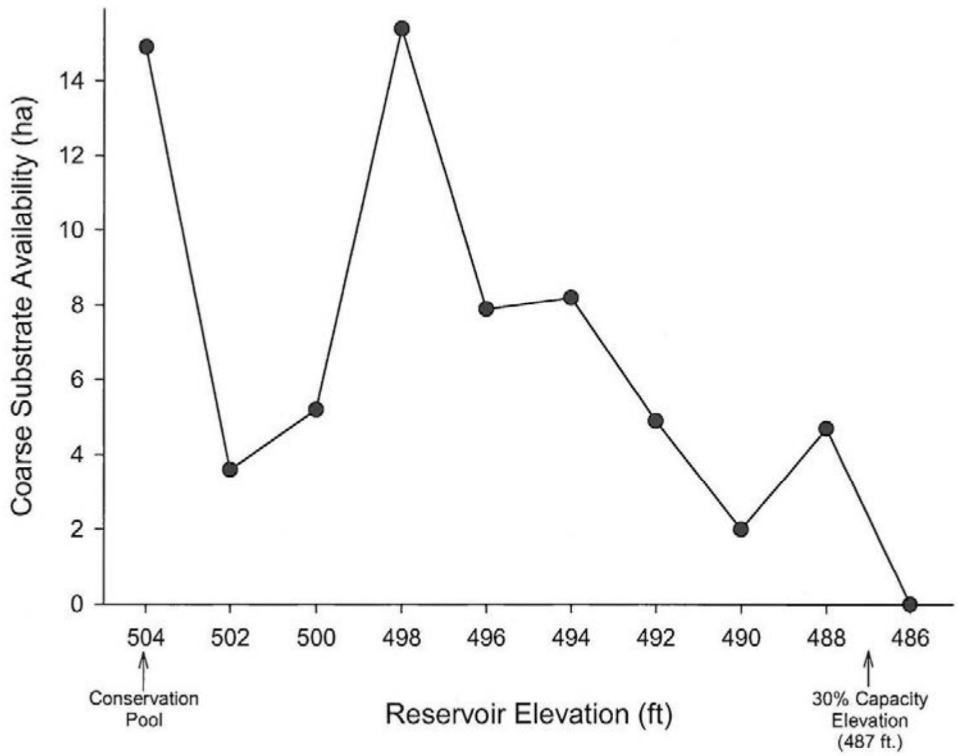


Figure 3. Elevation specific littoral zone (< 2 ft. water depth) woody and vegetative habitat availability in Granger Lake, Texas. Woody habitat was defined as one inundated standing tree, downed tree, or brush pile attractor.

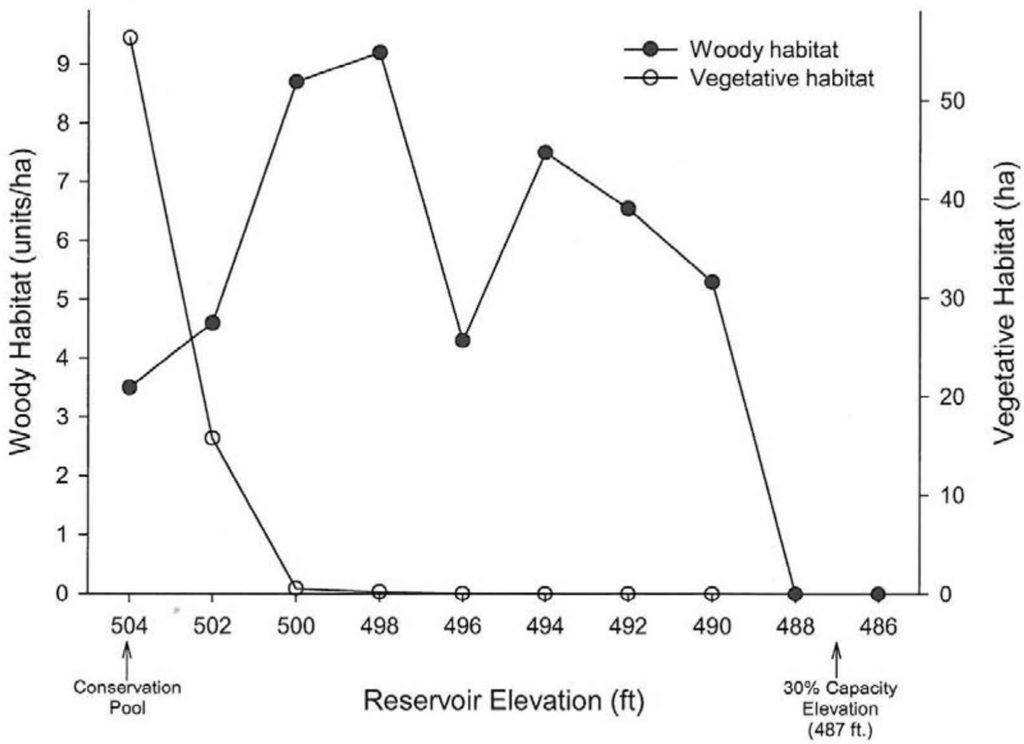
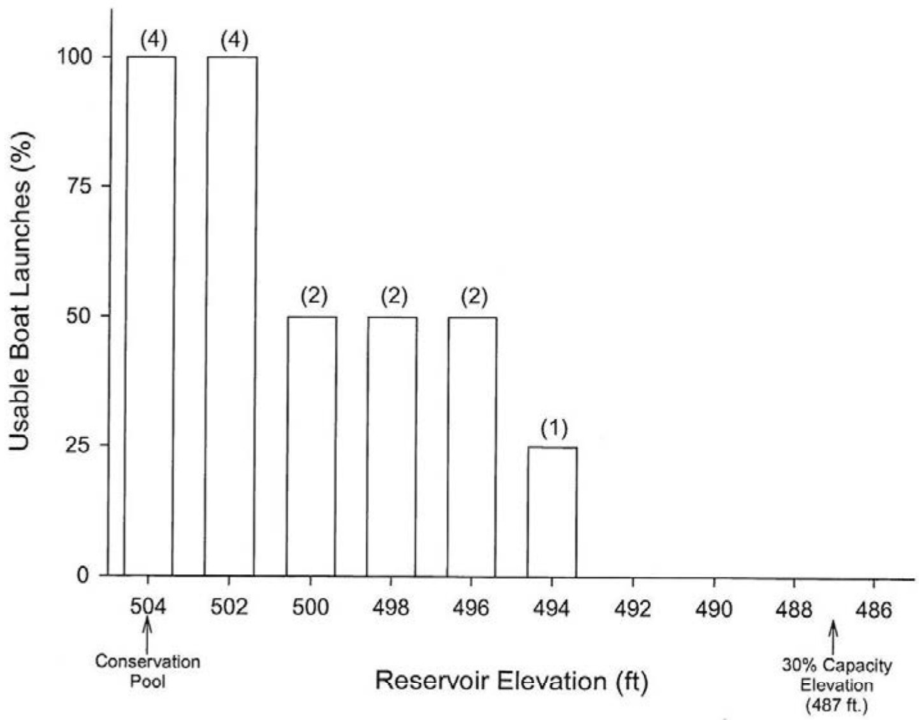


Figure 4. Elevation specific boat accessibility in Granger Lake, Texas. The number of usable boat launches provided above each bar.



## Lake Limestone

Figure 1. Elevation specific littoral zone (< 4 ft. water depth) coverage in Lake Limestone, Texas, for upper, middle, and lower reservoir reaches and all reaches combined.

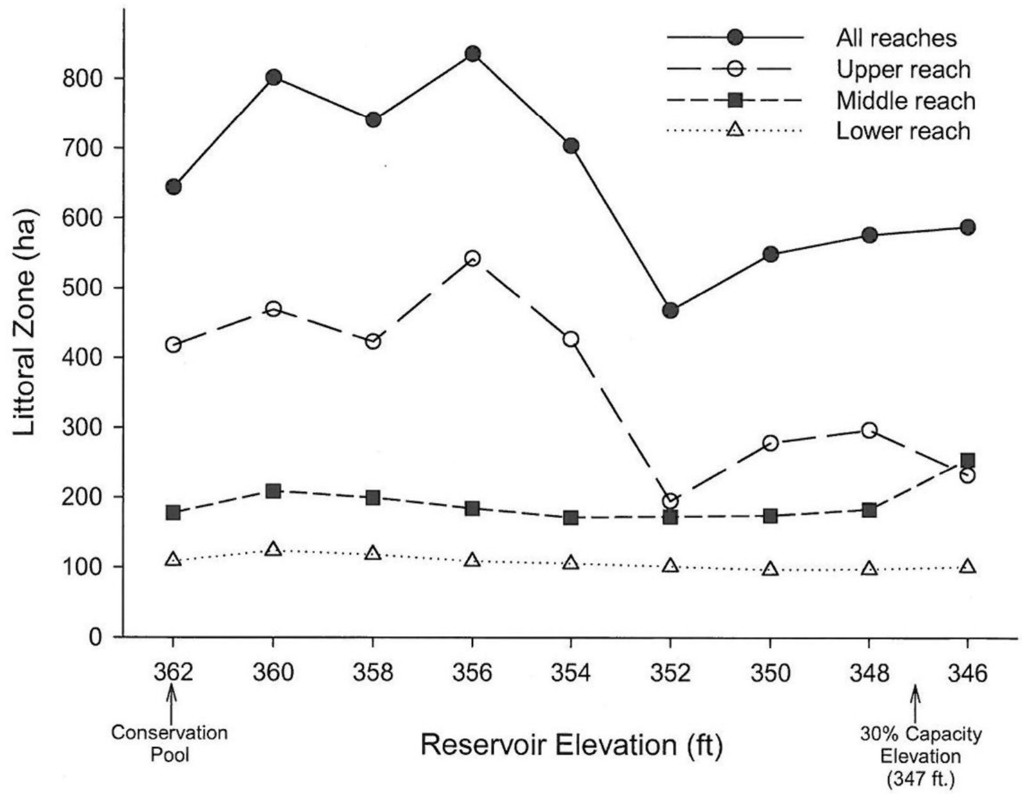


Figure 2. Elevation specific littoral zone (< 4 ft. water depth) coarse substrate availability in Lake Limestone, Texas.

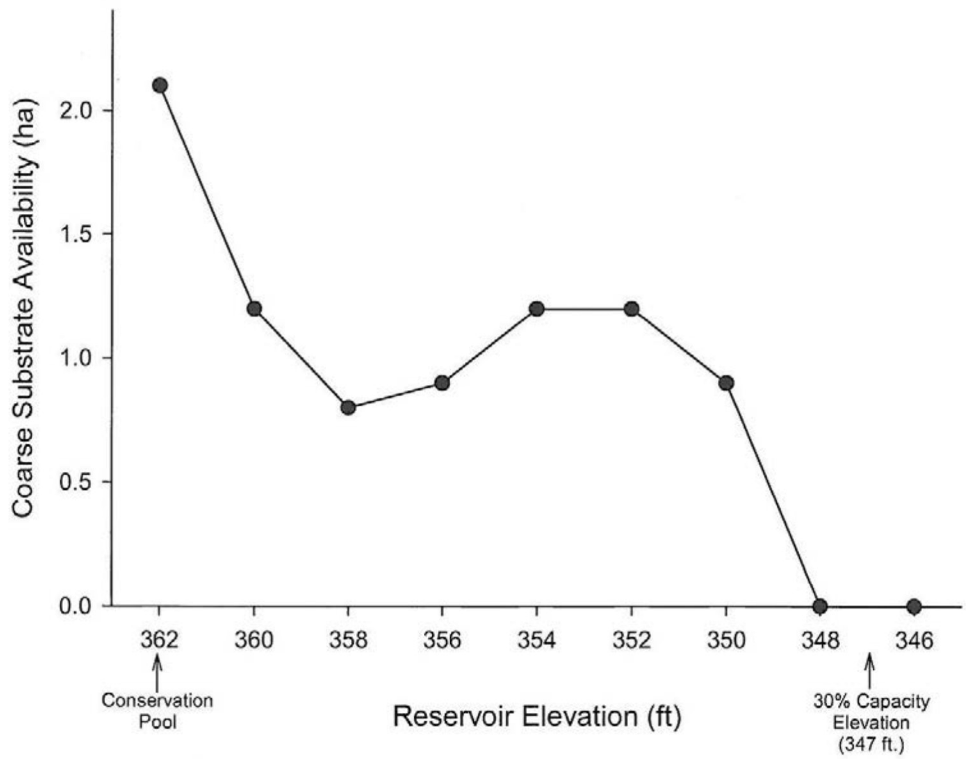


Figure 3. Elevation specific littoral zone (< 4 ft. water depth) woody habitat availability in Lake Limestone, Texas. Woody habitat was defined as one inundated standing tree, downed tree, or brush pile attractor.

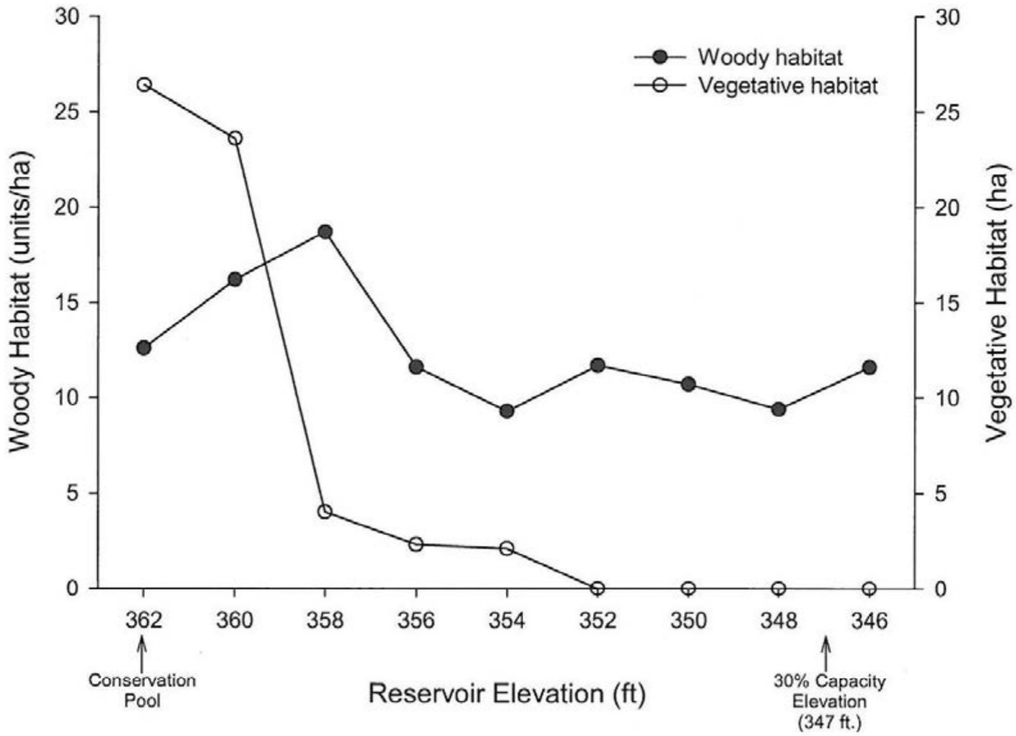
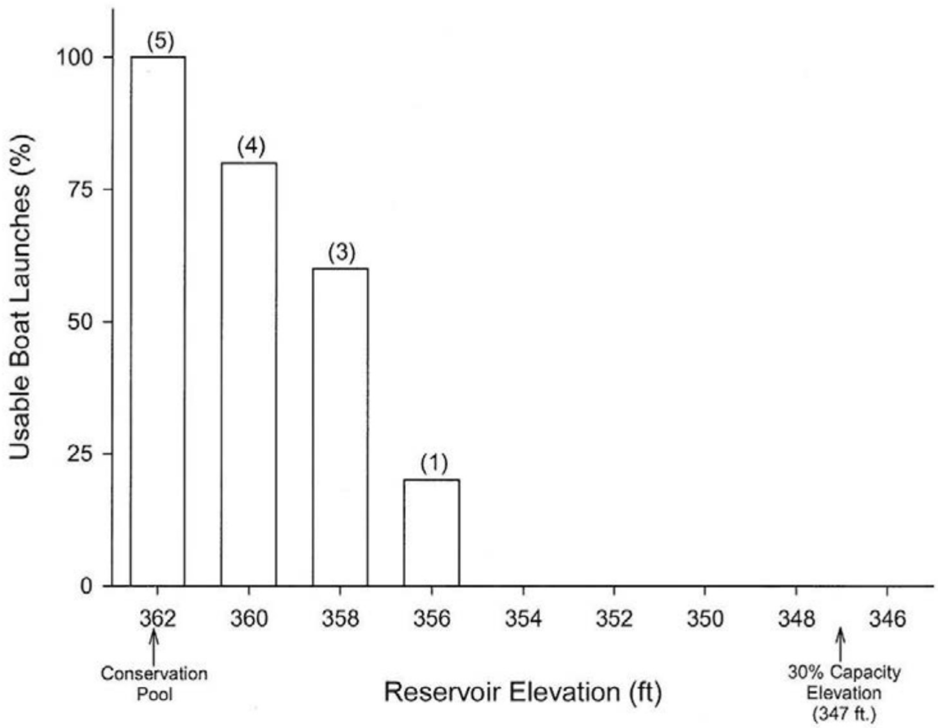


Figure 4. Elevation specific boat accessibility in Lake Limestone, Texas. The number of usable boat launches provided above each bar.



## Possum Kingdom Lake

Figure 1. Elevation specific littoral zone (< 10 ft. water depth) coverage in Possum Kingdom Reservoir, Texas, for upper, middle, and lower reservoir reaches and all reaches combined.

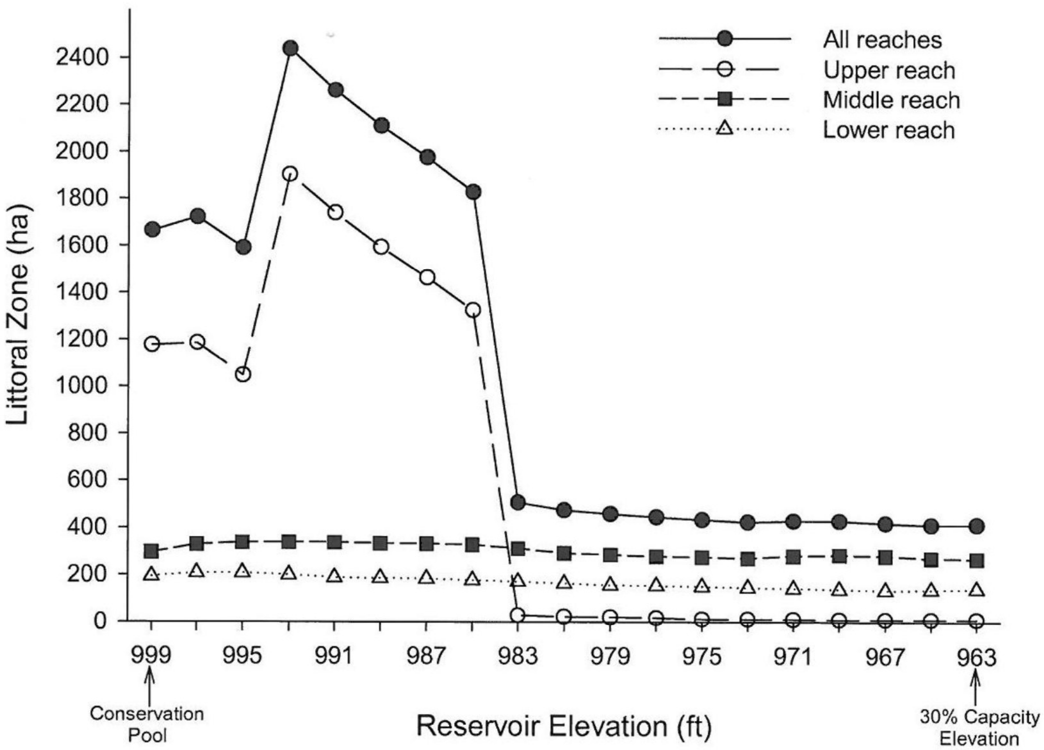


Figure 2. Elevation specific littoral zone (< 10 ft. water depth) coarse substrate availability in Possum Kingdom Reservoir, Texas.

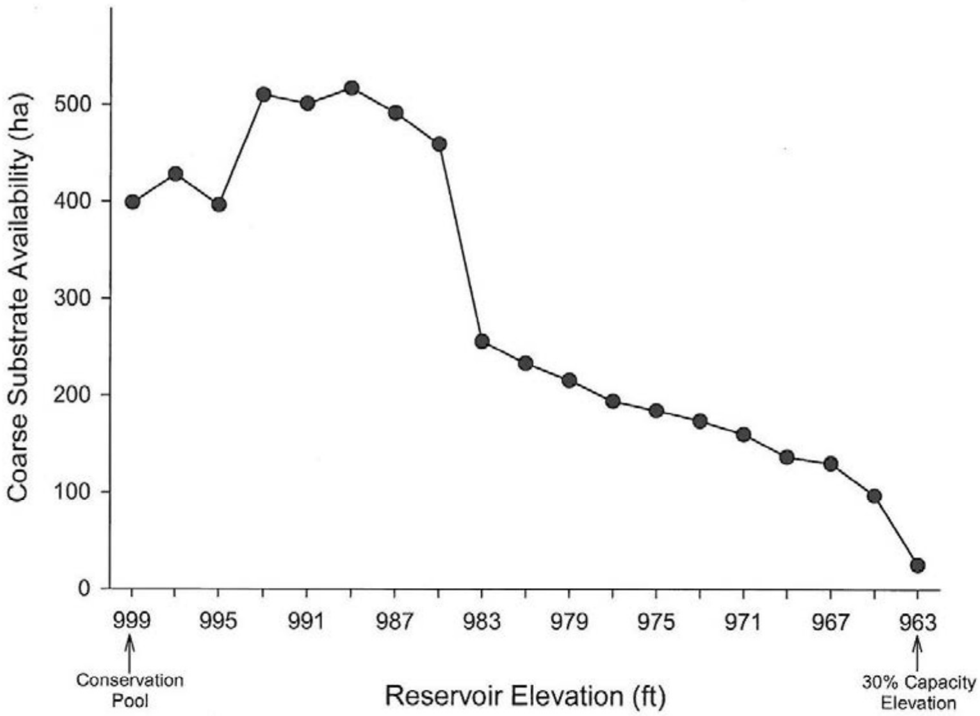


Figure 3. Elevation specific littoral zone (< 10 ft. water depth) woody habitat availability in Possum Kingdom Reservoir, Texas. Woody habitat was defined as one inundated standing tree, downed tree, or brush pile attractor.

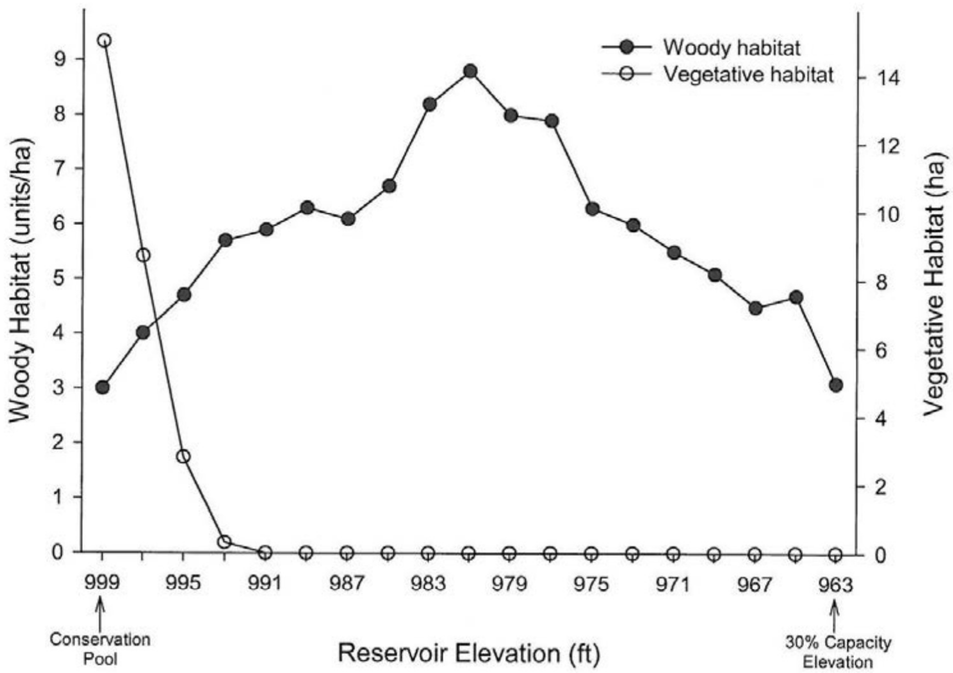
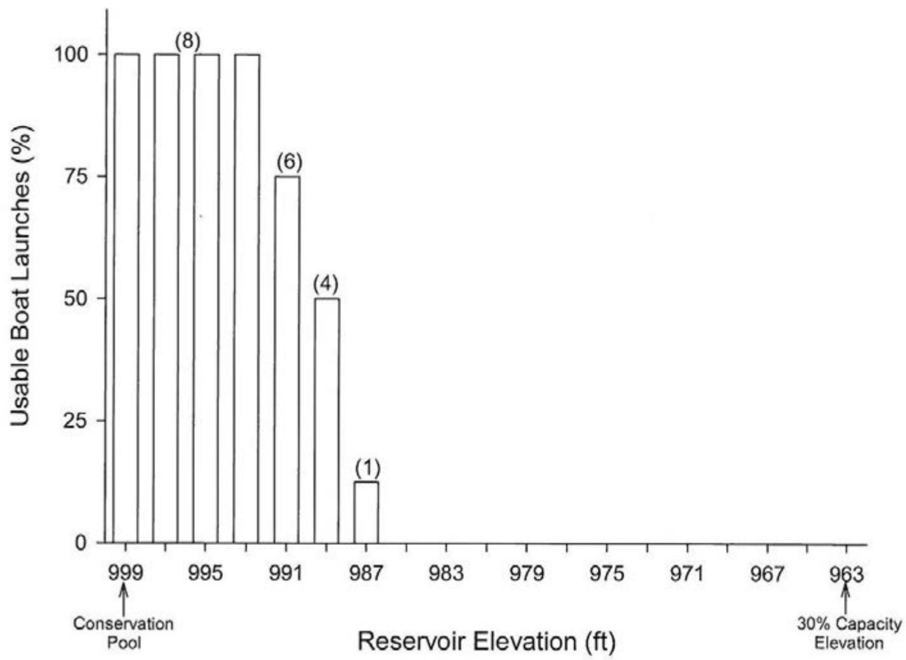


Figure 4. Elevation specific boat accessibility in Possum Kingdom Reservoir, Texas. The number of usable boat launches provided above each bar.



## Lake Proctor

Figure 1. Elevation specific littoral zone (< 6 ft. water depth) coverage in Lake Proctor, Texas for upper, middle, and lower reservoir reaches and all reaches combined.

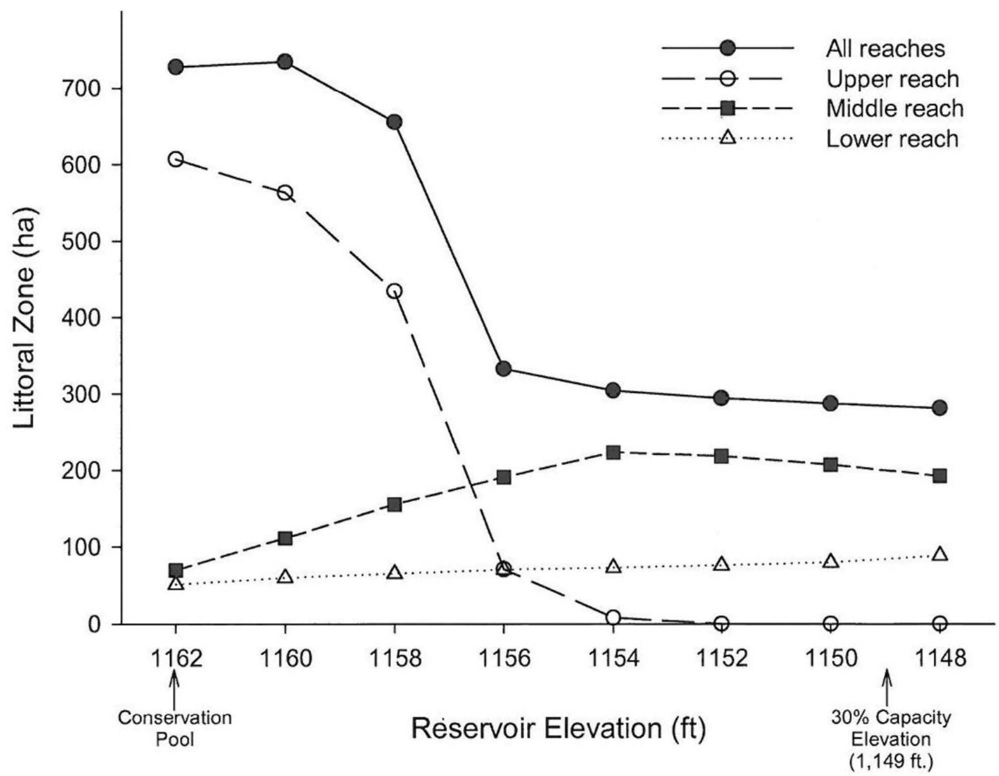


Figure 2. Elevation specific littoral zone (< 6 ft. water depth) coarse substrate availability in Lake Proctor, Texas.

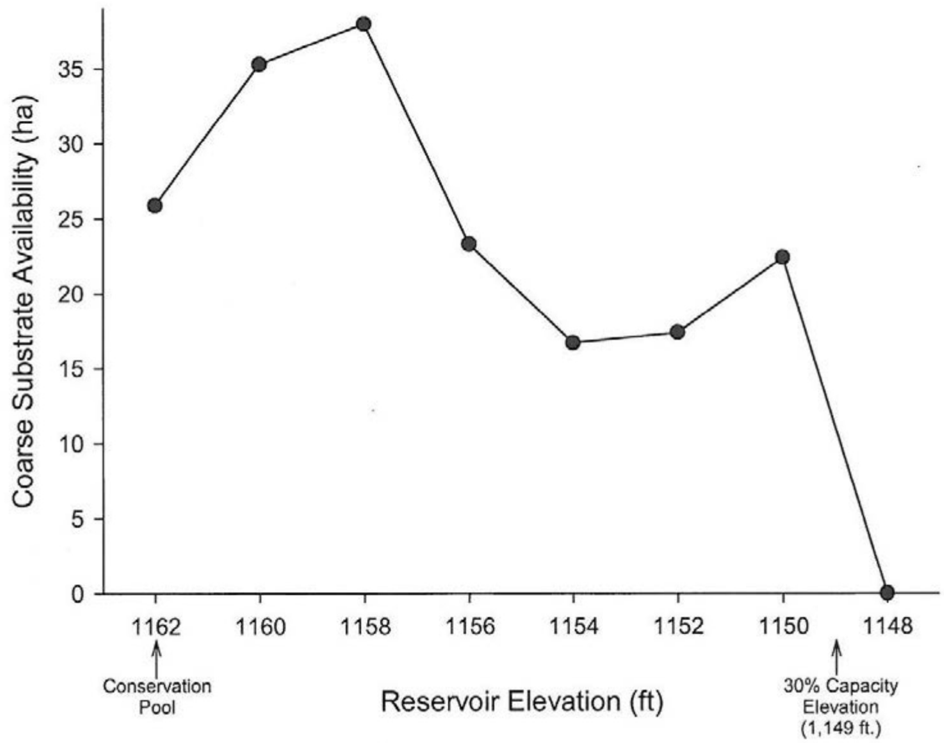


Figure 3. Elevation specific littoral zone (< 6 ft. water depth) woody and vegetative habitat availability in Lake Proctor, Texas. Woody habitat was defined as one inundated standing tree, downed tree, or brush pile attractor.

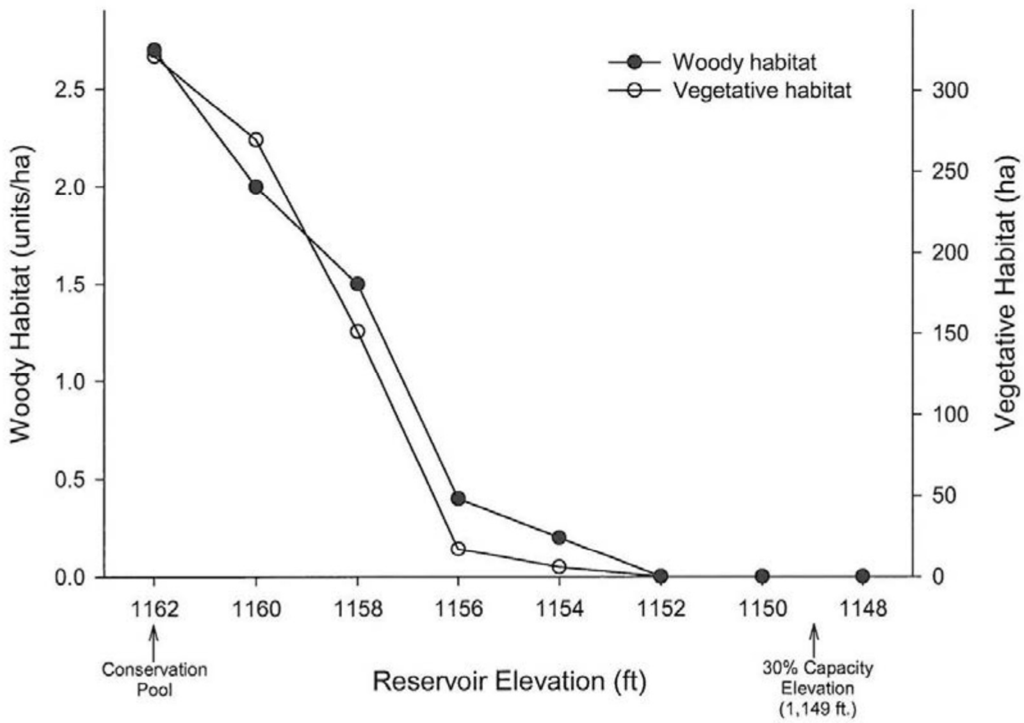
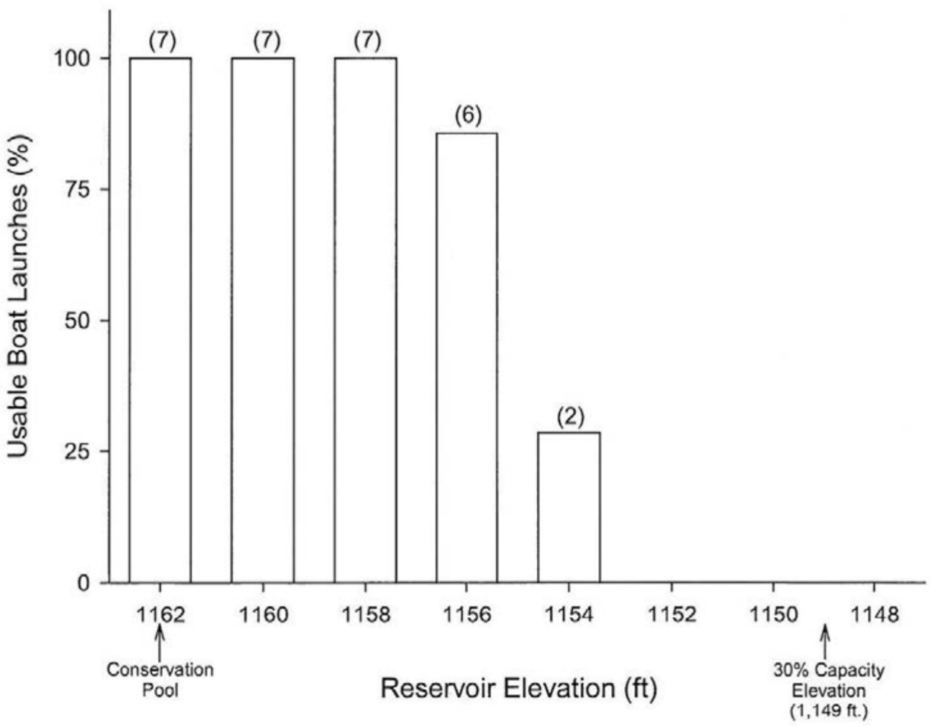


Figure 4. Elevation specific boat accessibility in Lake Proctor, Texas. The number of usable boat launches provided above each bar.



## Lake Somerville

Figure 1. Elevation specific littoral zone (< 14 ft. water depth) coverage in Lake Somerville, Texas, for upper, middle, and lower reservoir reaches and all reaches combined.

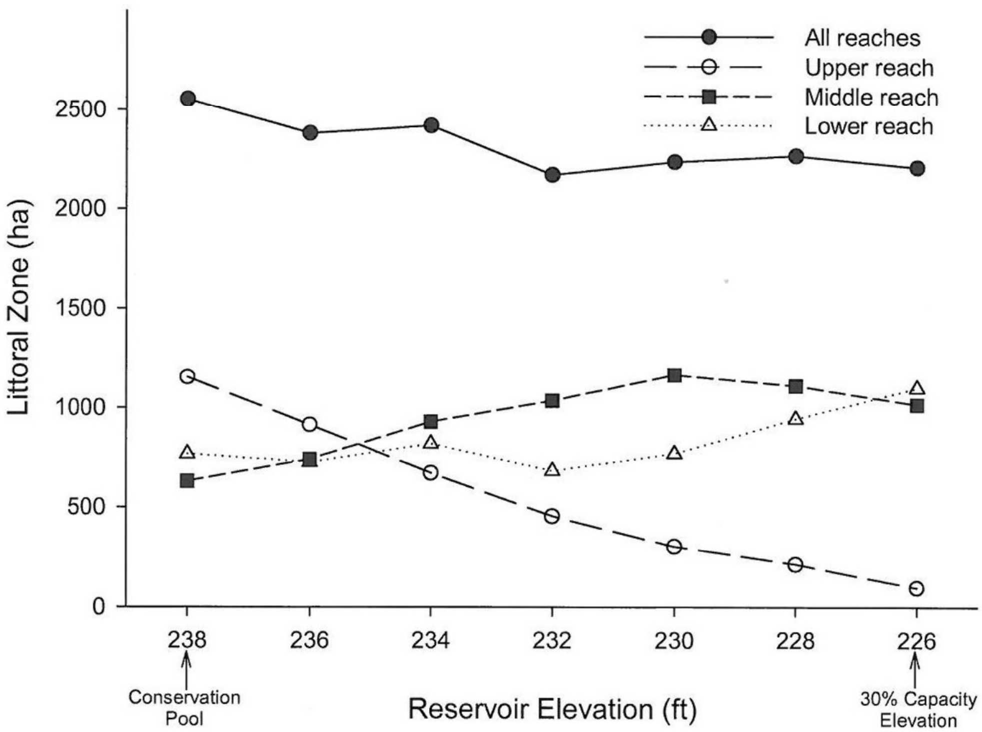


Figure 2. Elevation specific littoral zone (< 14 ft. water depth) coarse substrate availability in Lake Somerville, Texas.

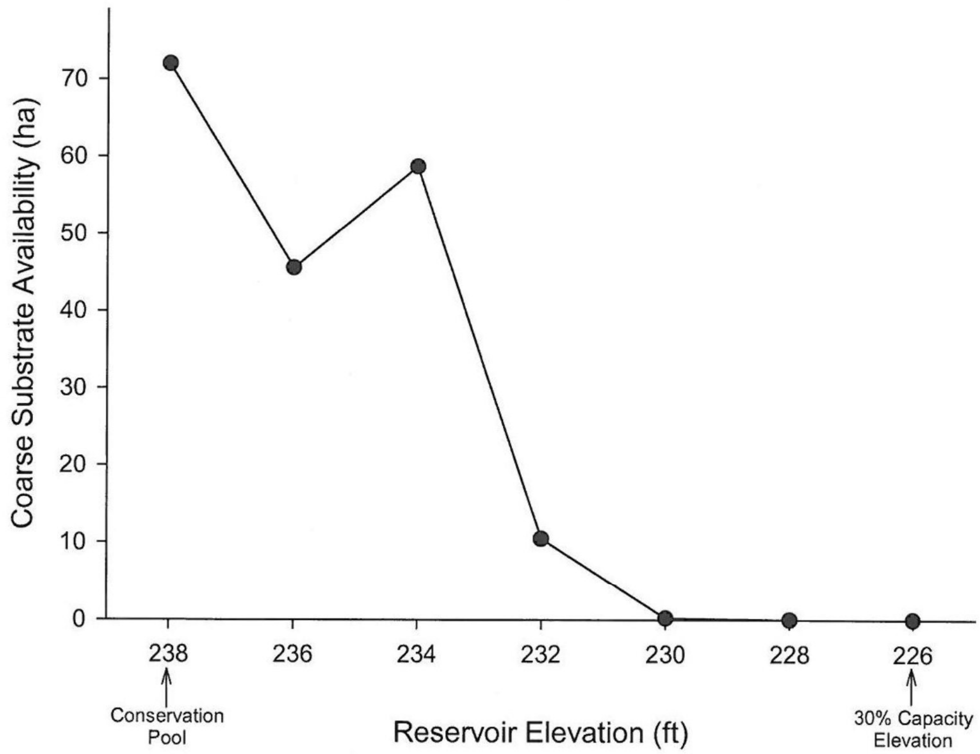


Figure 3. Elevation specific littoral zone (< 14 ft. water depth) woody habitat availability in Lake Somerville, Texas. Woody habitat was defined as one inundated standing tree, downed tree, or brush pile attractor.

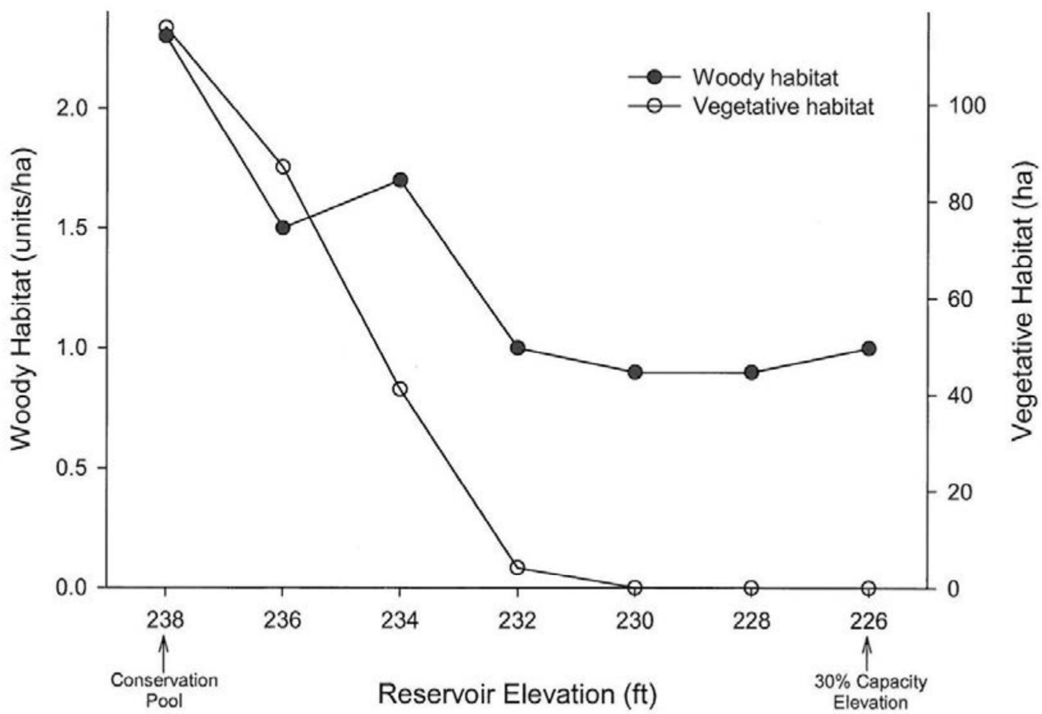
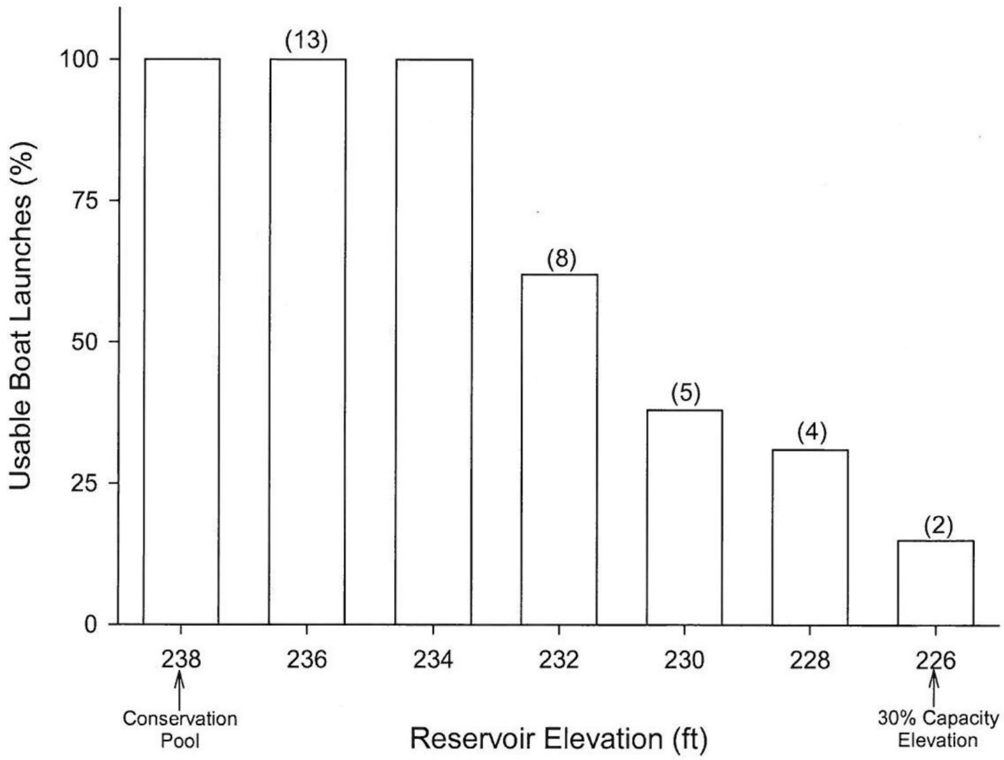


Figure 4. Elevation specific boat accessibility in Lake Somerville, Texas. The number of usable boat launches provided above each bar.



## Lake Stillhouse Hollow

Figure 1. Elevation specific littoral zone (< 12 ft. water depth) coverage in Stillhouse Hollow Reservoir, Texas, for upper, middle, and lower reservoir reaches and all reaches combined.

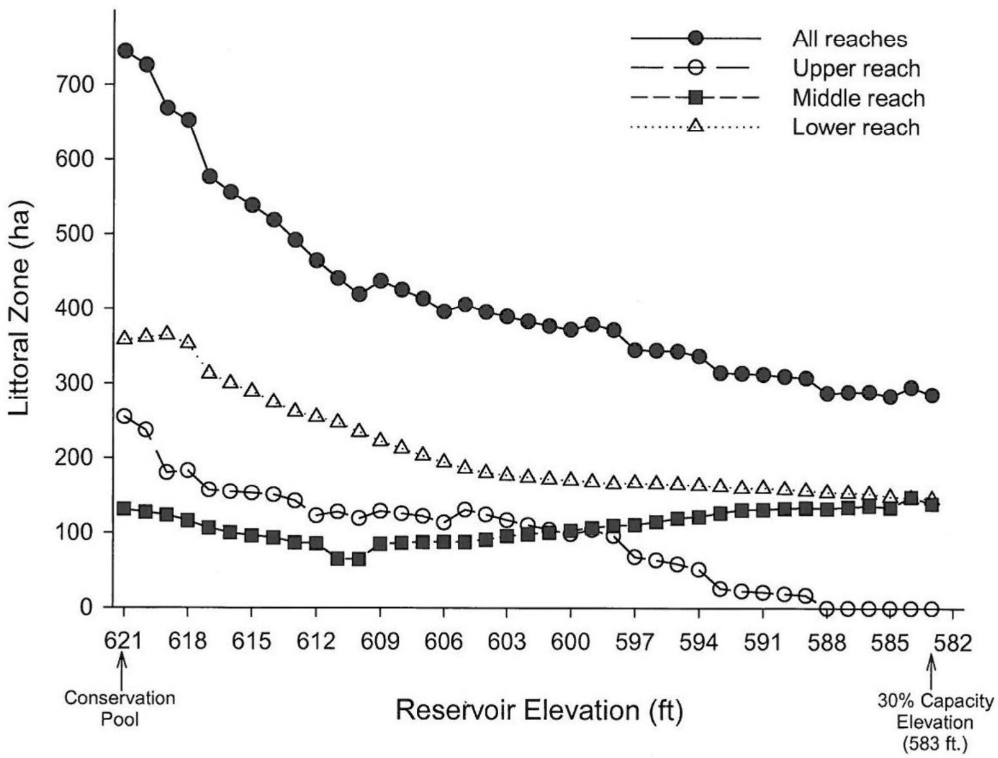


Figure 2. Elevation specific littoral zone (< 12 ft. water depth) coarse substrate availability in Stillhouse Hollow Reservoir, Texas.

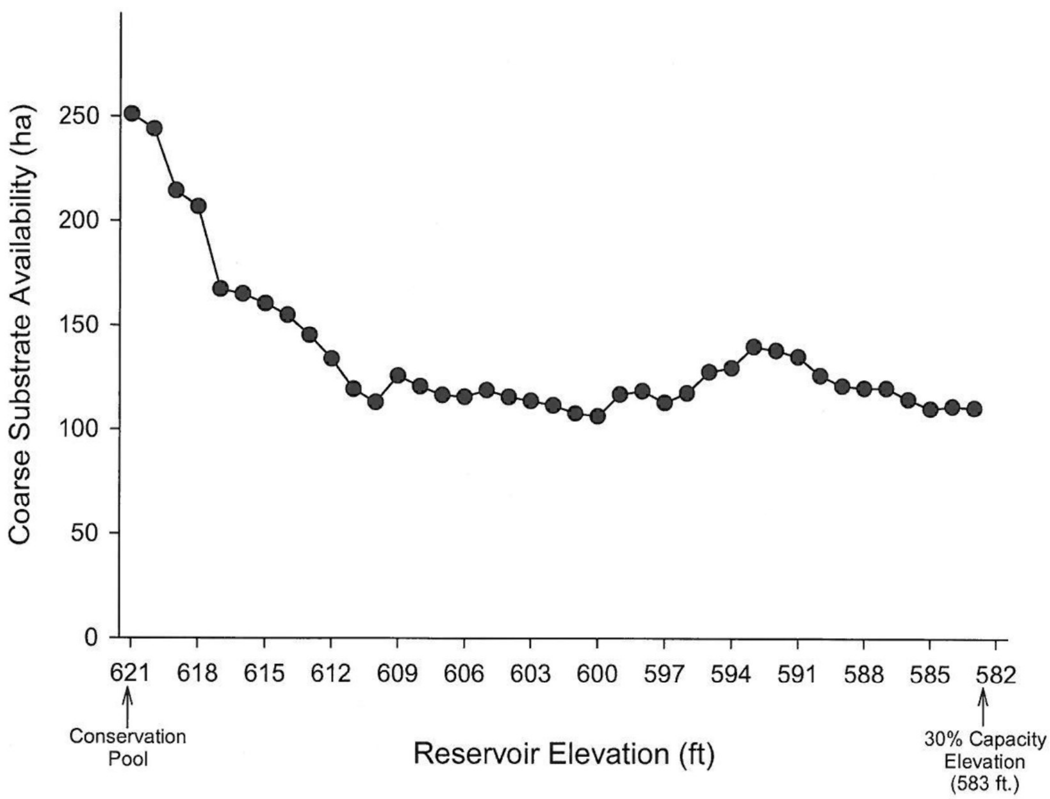


Figure 3. Elevation specific littoral zone (< 12 ft. water depth) woody habitat availability in Stillhouse Hollow Reservoir, Texas. Woody habitat was defined as one inundated standing tree, downed tree, or brush pile attractor.

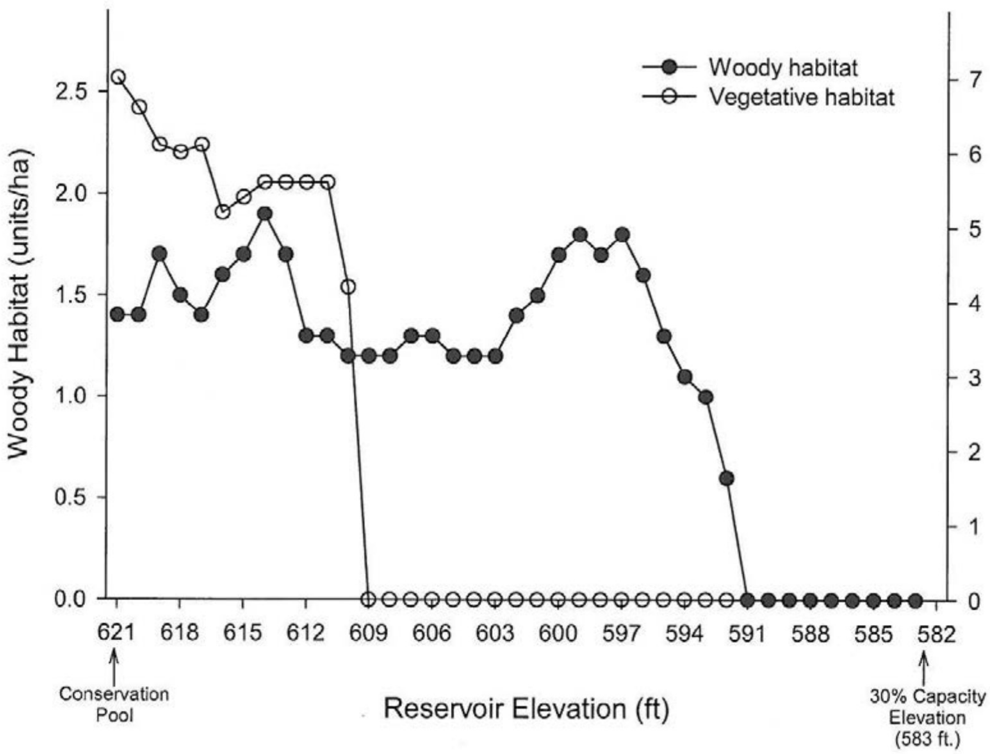
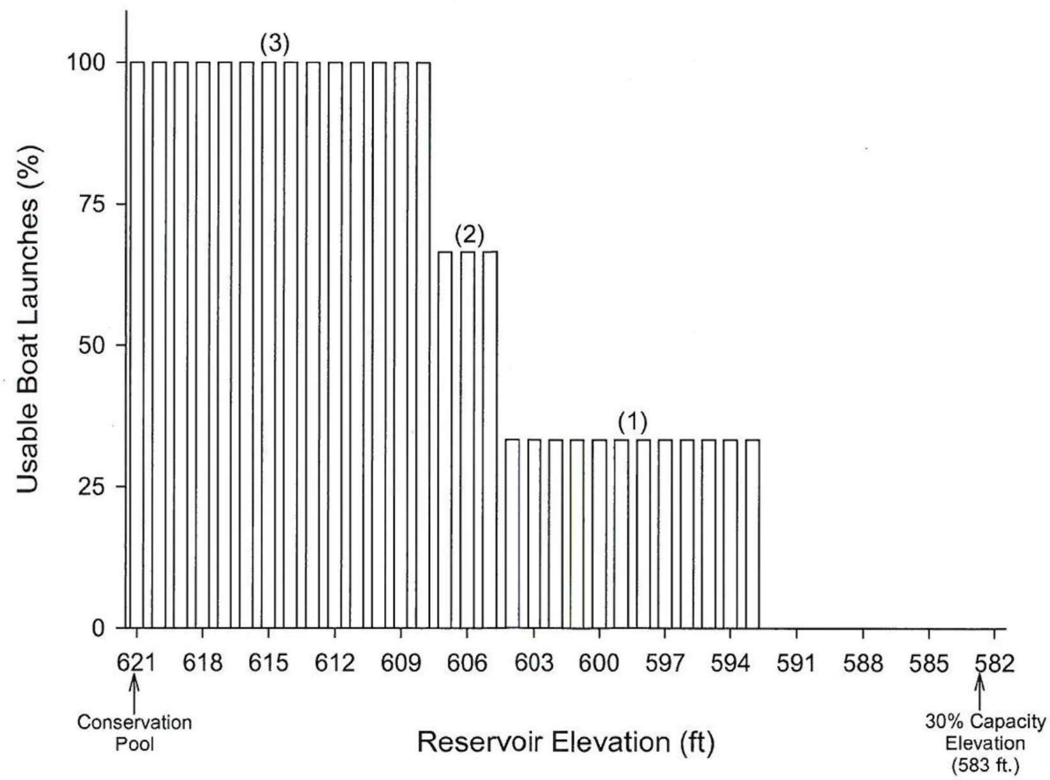


Figure 4. Elevation specific boat accessibility in Stillhouse Hollow Reservoir, Texas. The number of usable boat launches provided above each bar.



Lake Whitney

Figure 1. Elevation specific littoral zone (< 8 ft. water depth) coverage in Lake Whitney, Texas, for upper, middle, and lower reservoir reaches and all reaches combined. *Elevation-specific data could not be derived for the 533-ft contour; therefore, 532 ft. was used as a surrogate measure of conservation pool.

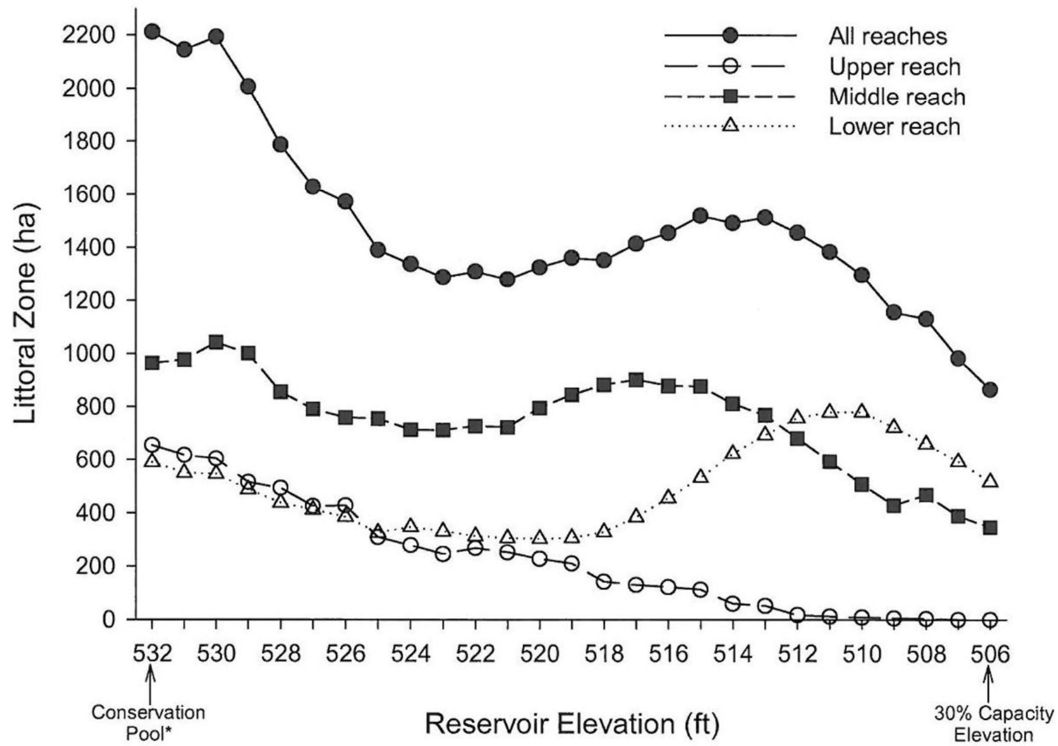


Figure 2. Elevation specific littoral zone (< 8 ft. water depth) coarse substrate availability in Lake Whitney, Texas. *Elevation-specific data could not be derived for the 533-ft contour; therefore, 532 ft. was used as a surrogate measure of conservation pool.

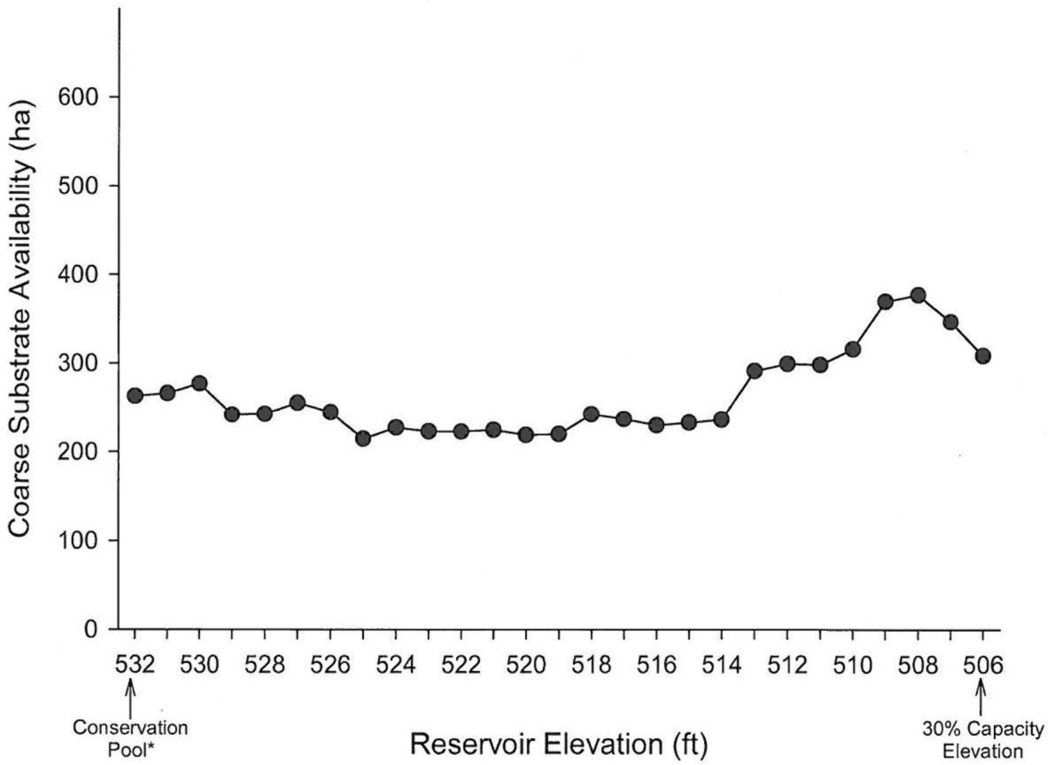


Figure 3. Elevation specific littoral zone (< 8 ft. water depth) woody habitat availability in Lake Whitney, Texas. Woody habitat was defined as one inundated standing tree, downed tree, or brush pile attractor. *Elevation-specific data could not be derived for the 533-ft contour; therefore, 532 ft. was used as a surrogate measure of conservation pool.

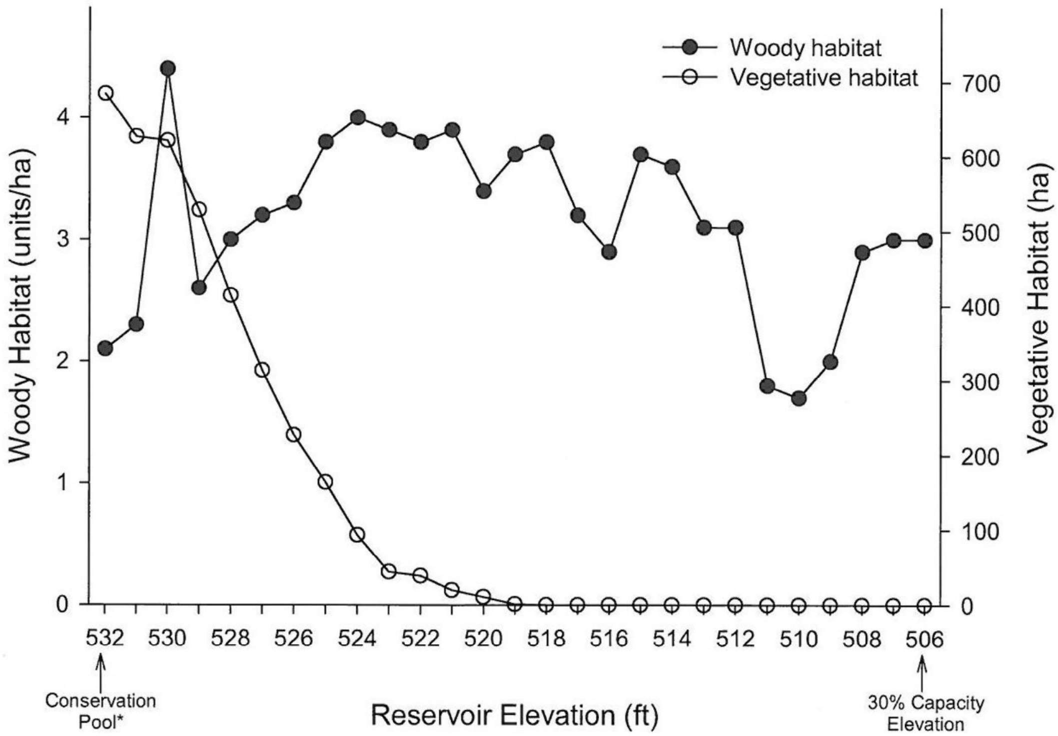
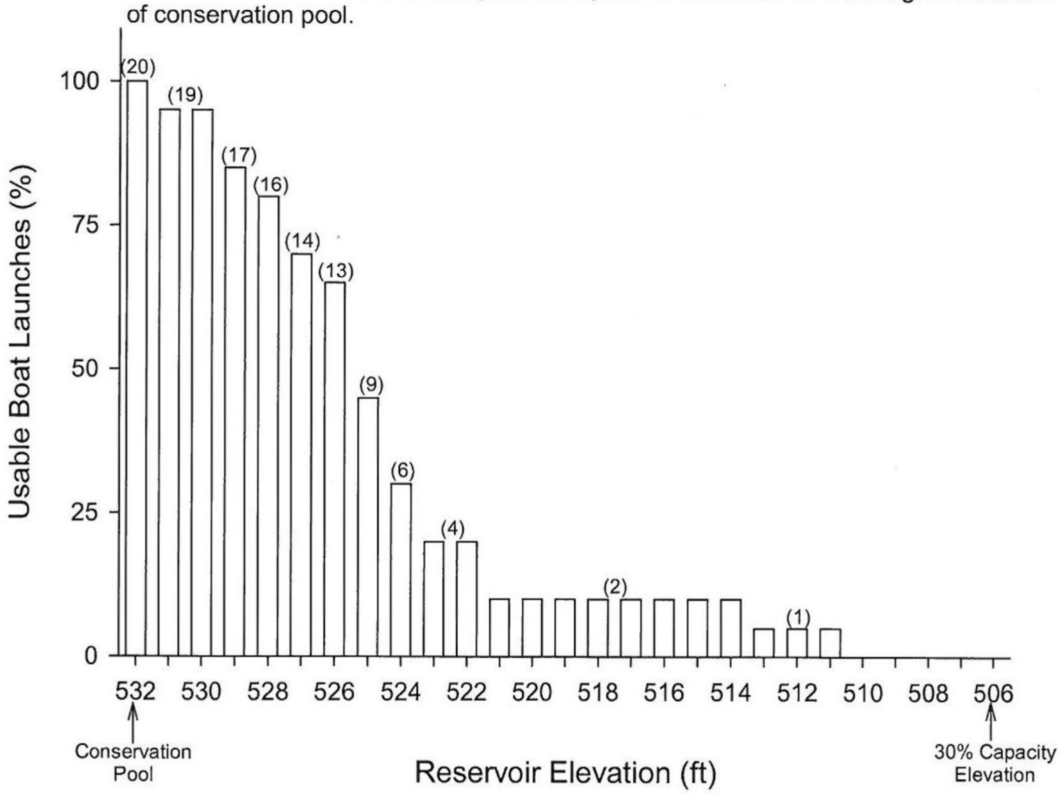
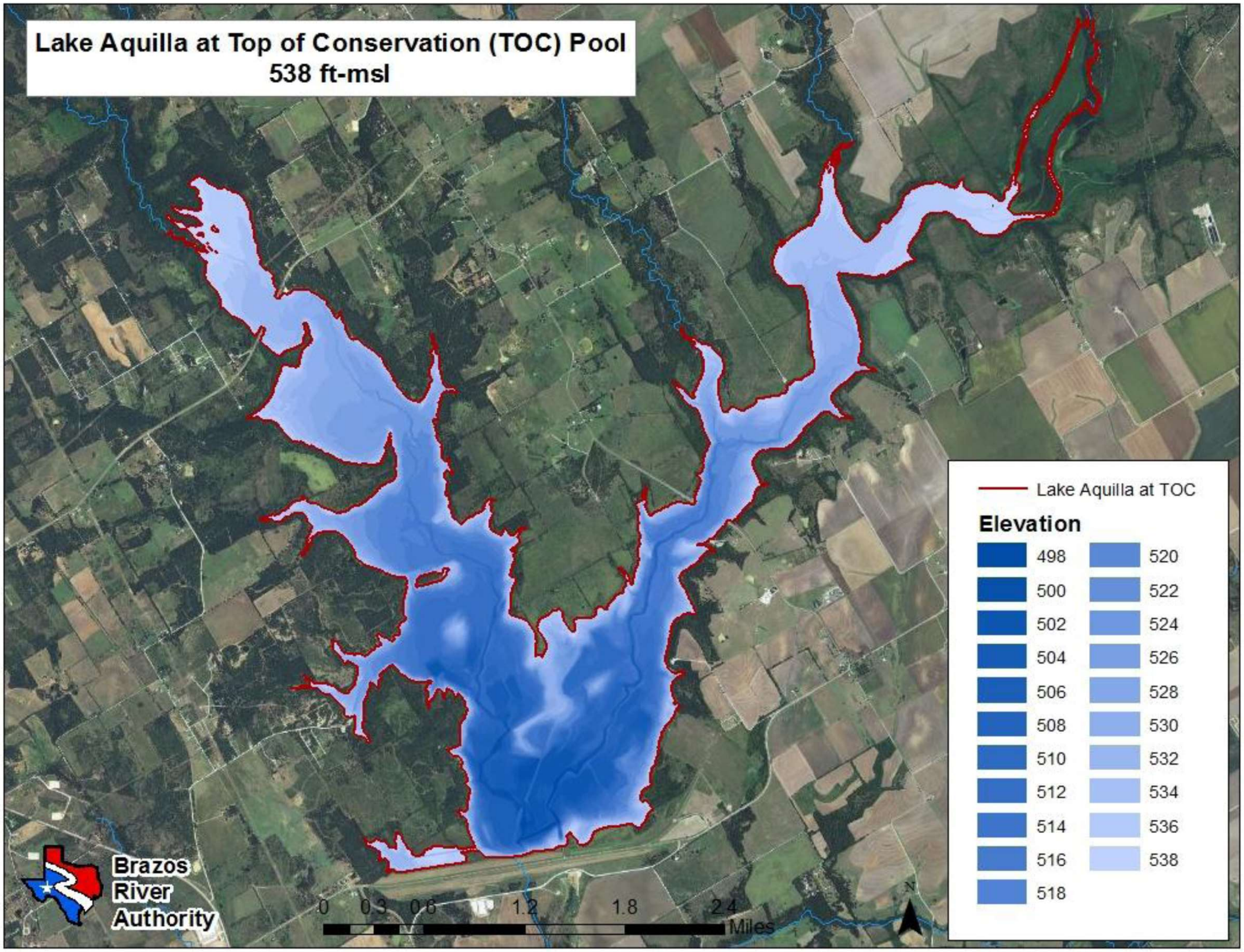
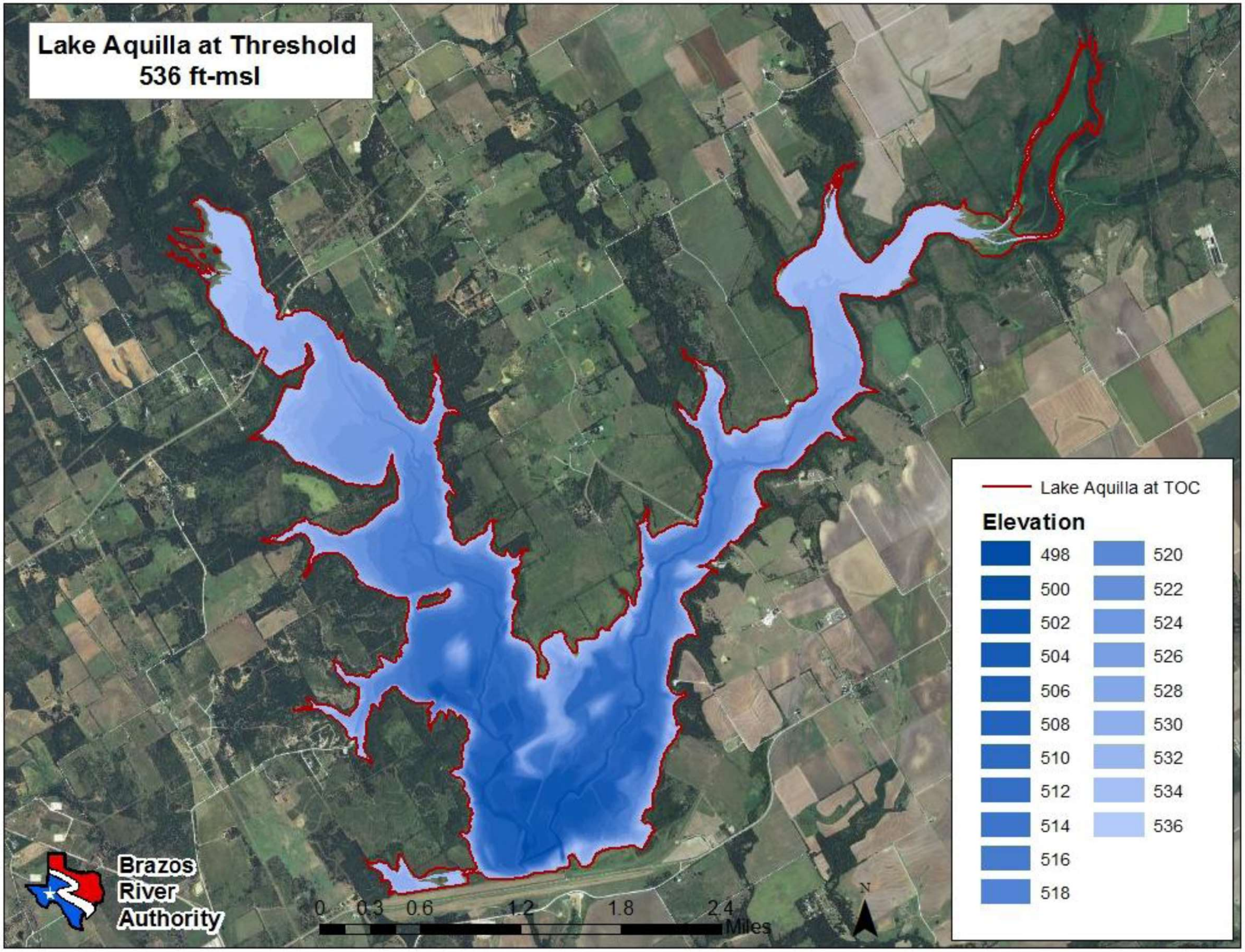


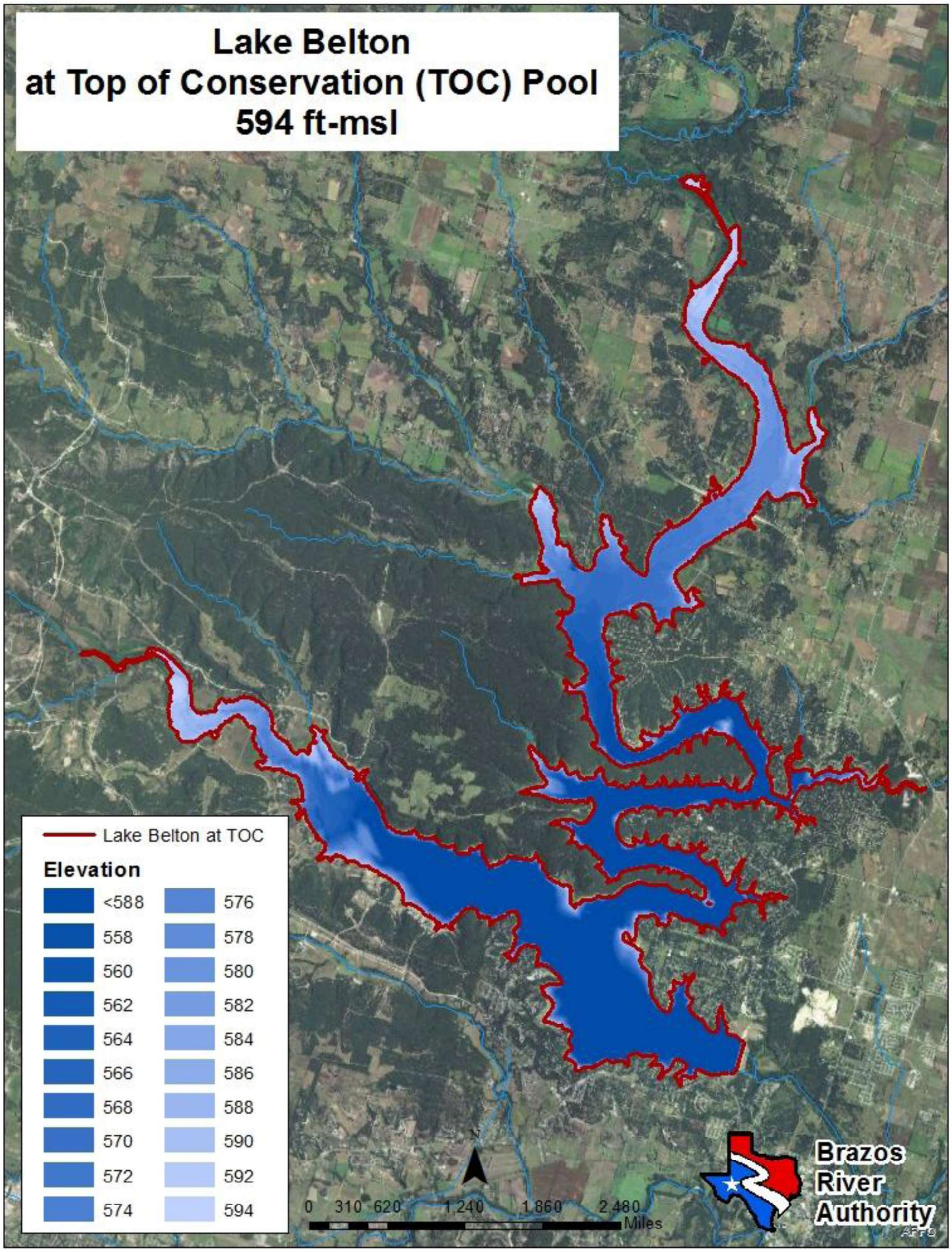
Figure 4. Elevation specific boat accessibility in Lake Whitney, Texas. The number of usable boat launches provided above each bar. *Elevation-specific data could not be derived for the 533-ft contour; therefore, 532 ft. was used as a surrogate measure of conservation pool.



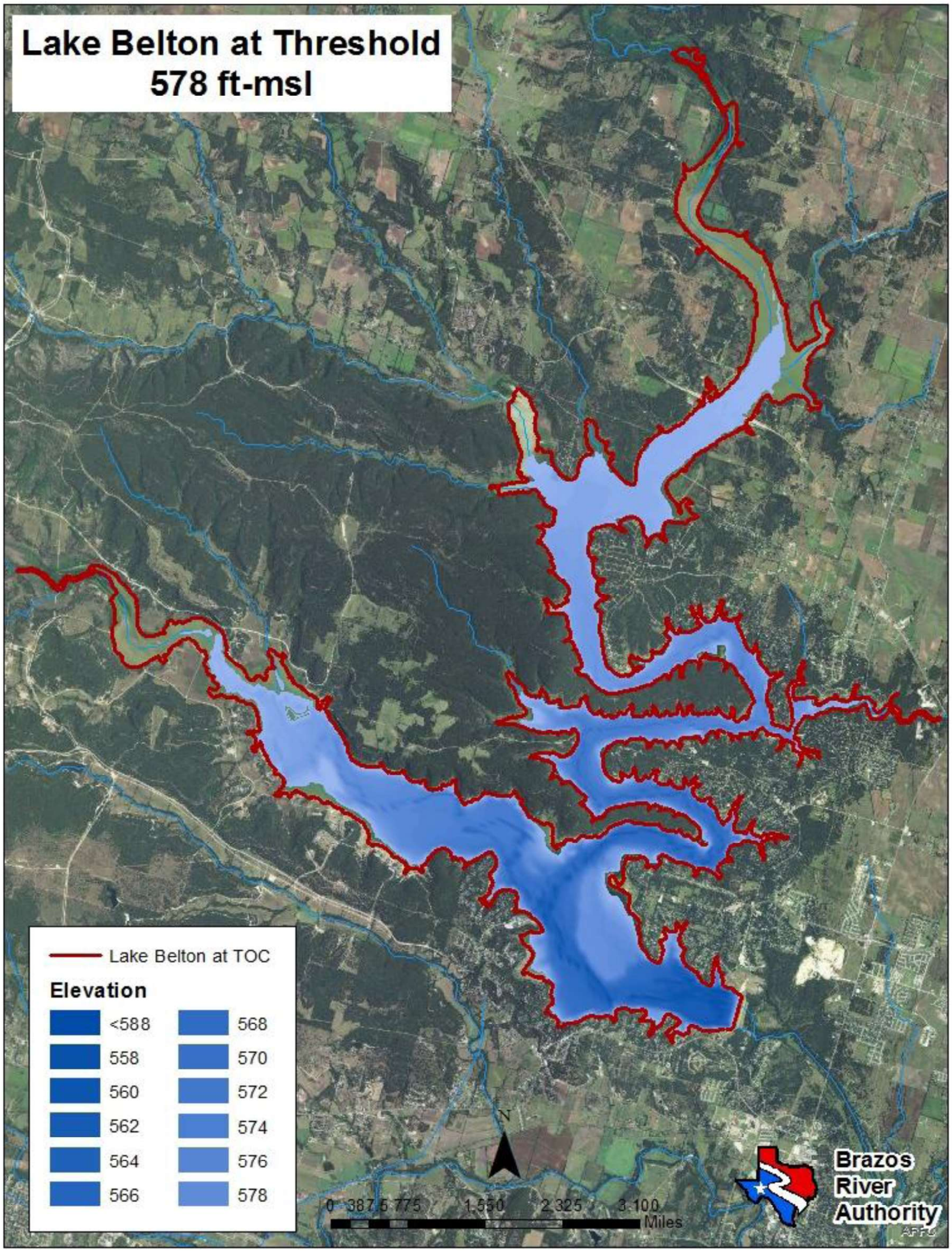
# Appendix C
# Reservoir Maps at TOC and Threshold

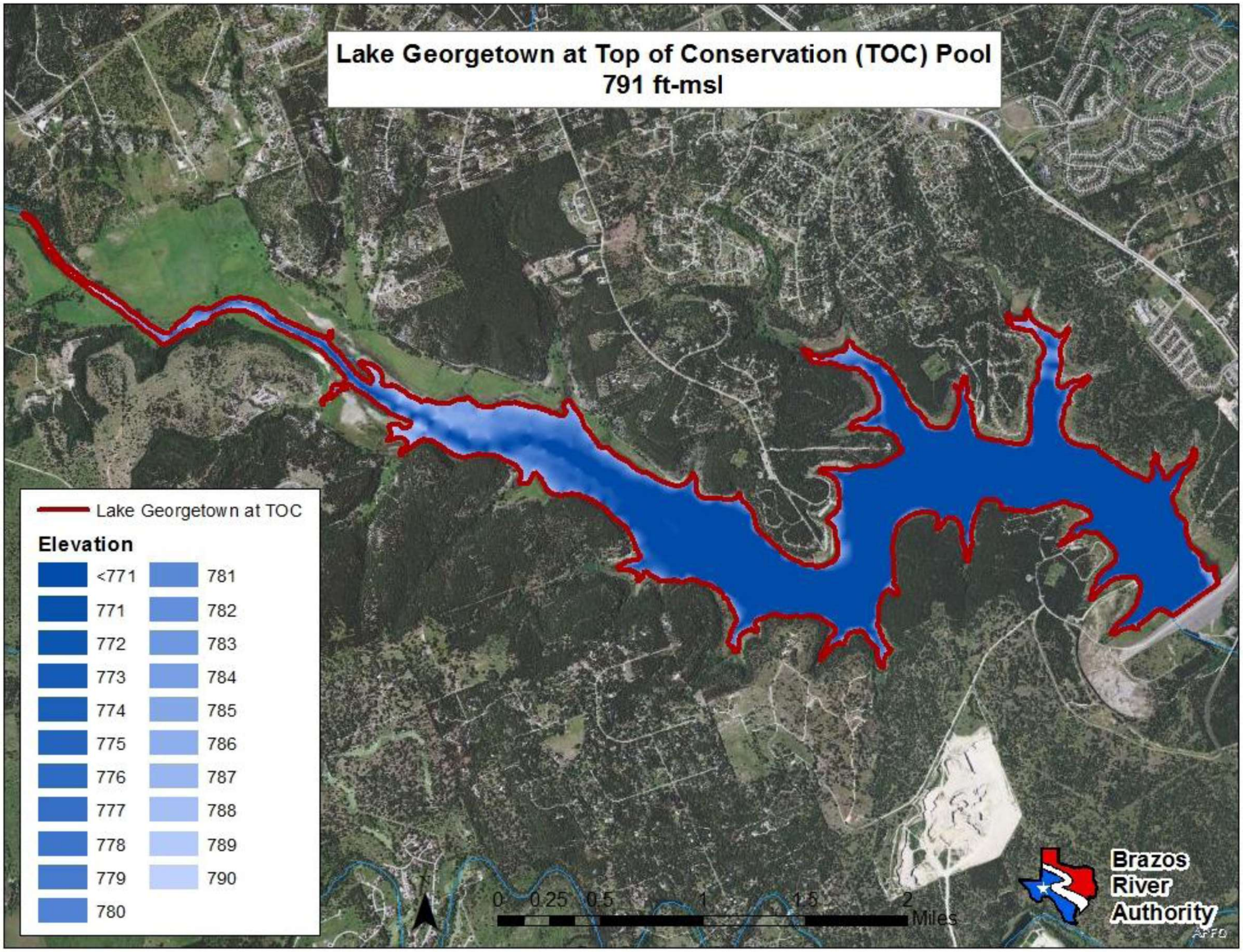

Lake Aquilla at Top of Conservation (TOC) Pool
538 ft-msl
Lake Aquilla at TOC
Elevation
498
500
502
504
506
508
510
512
514
516
518
520
522
524
526
528
530
532
534
536
538
0 0.3 0.6 1.2 1.8 2.4
Miles
N
Brazos River Authority

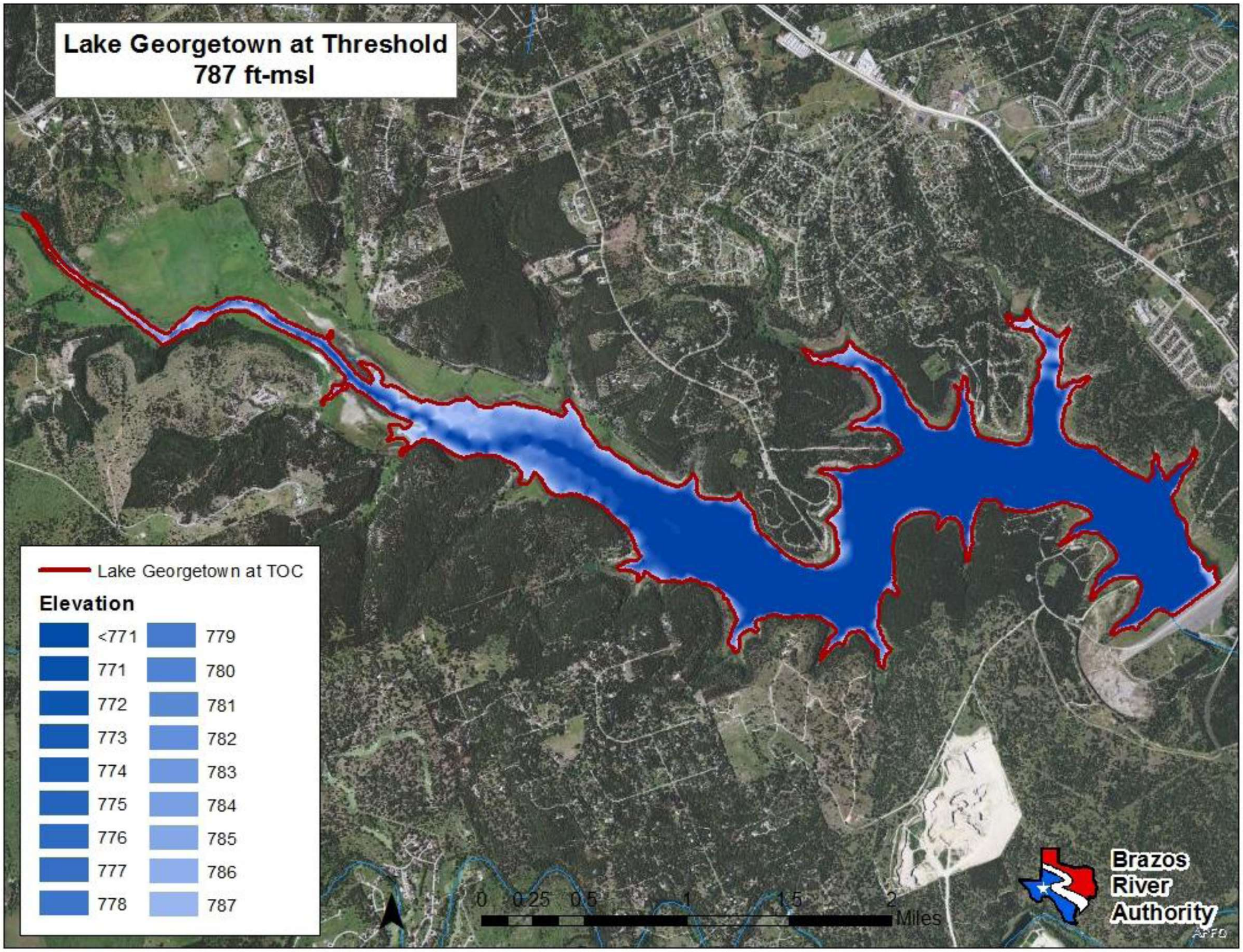

Lake Aquilla at Threshold
536 ft-msl
Lake Aquilla at TOC
Elevation
498
500
502
504
506
508
510
512
514
516
518
520
522
524
526
528
530
532
534
536
0
0.3
0.6
1.2
1.8
2.4
Miles
N
Brazos
River
Authority

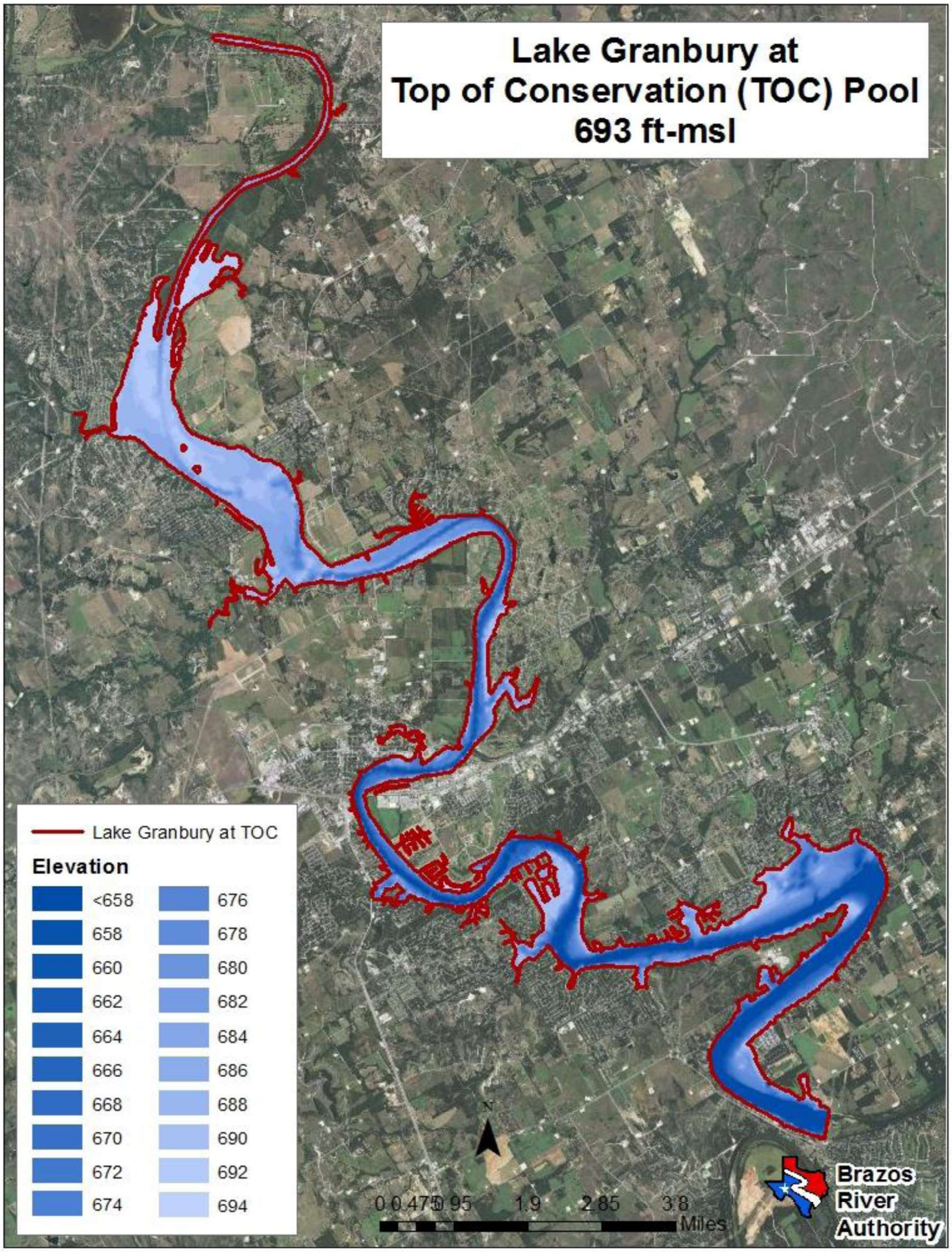


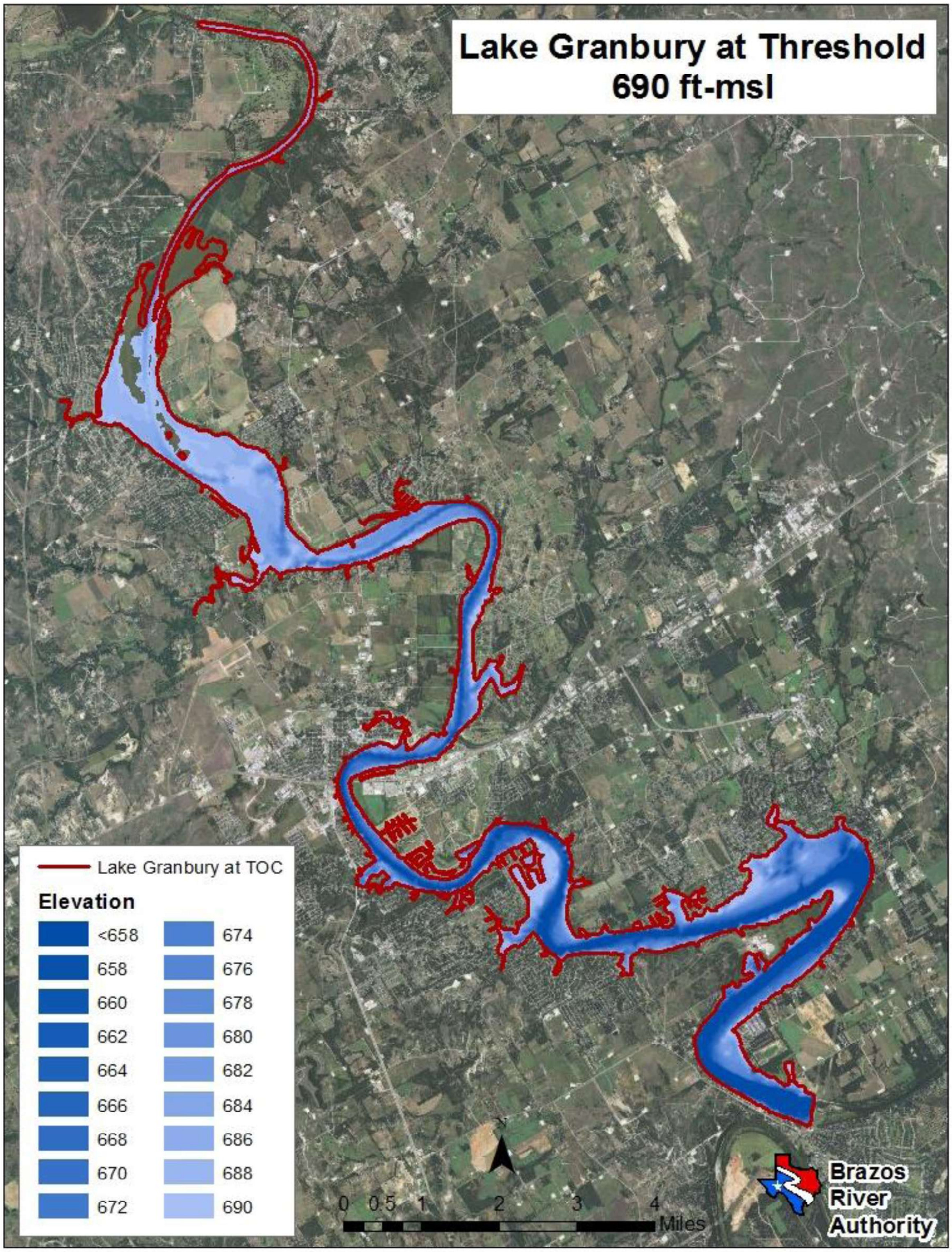
Lake Belton
at Top of Conservation (TOC) Pool
594 ft-msl
Lake Belton at TOC
Elevation
<588
558
560
562
564
566
568
570
572
574
576
578
580
582
584
586
588
590
592
594
0 310 620 1,240 1,860 2,480
Miles
Brazos
River
Authority

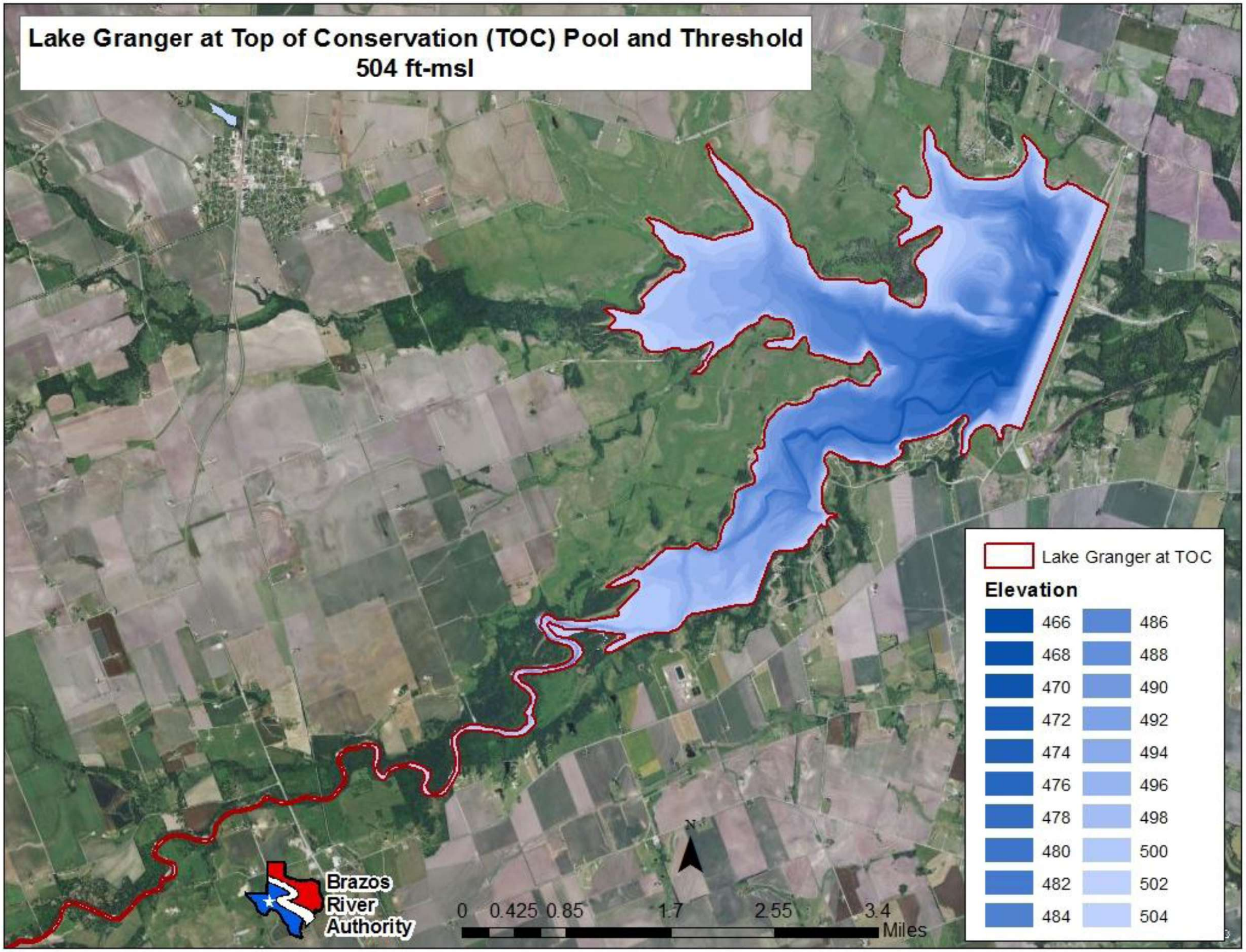

Lake Belton at Threshold
578 ft-msl
Lake Belton at TOC
Elevation
<588
558
560
562
564
566
568
570
572
574
576
578
N
0 387.5 775 1,550 2,325 3,100
Miles
Brazos
River
Authority

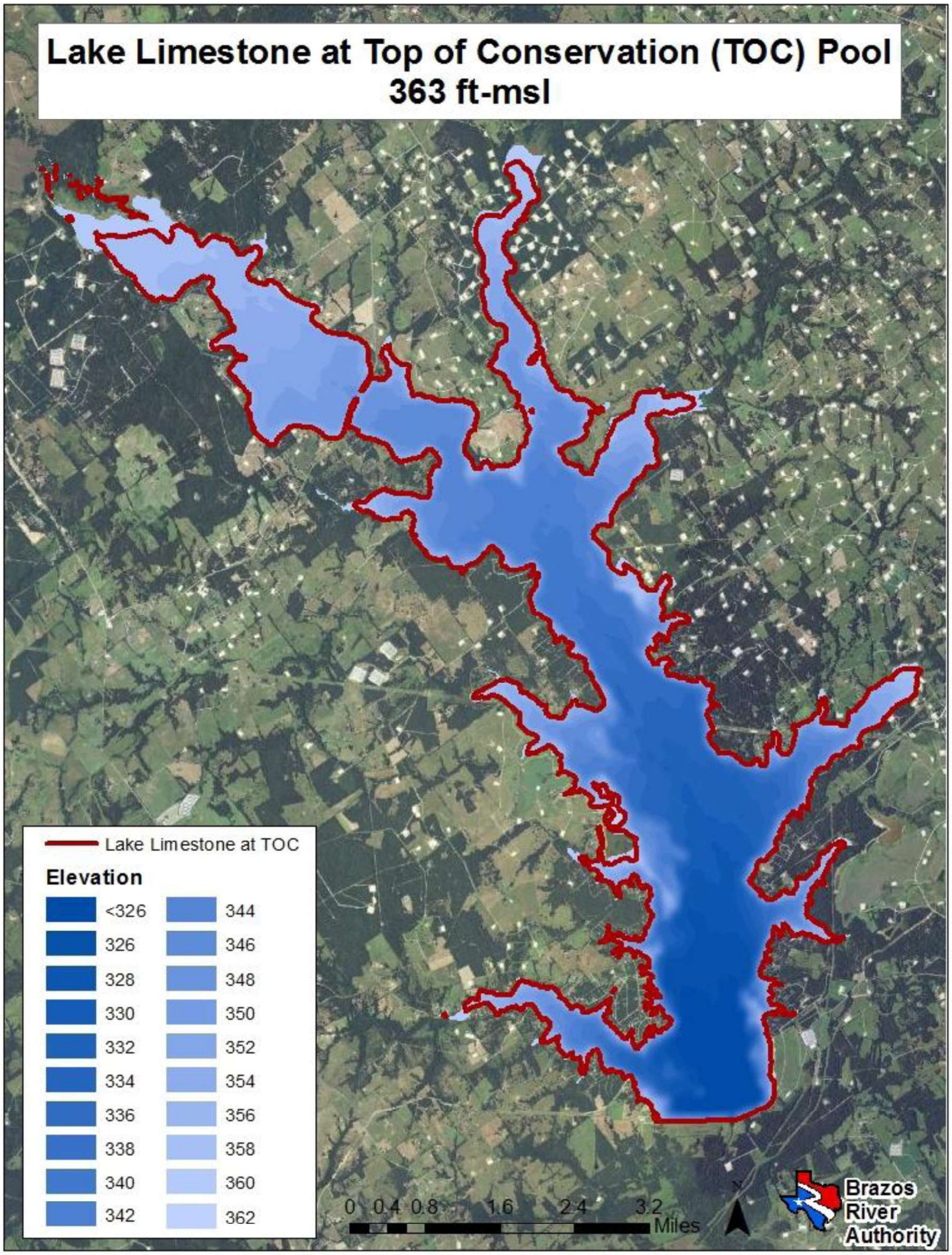

Lake Georgetown at Top of Conservation (TOC) Pool
791 ft-msl
Lake Georgetown at TOC
Elevation
<771
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
0
0.25
0.5
1
1.5
2
Miles
Brazos
River
Authority

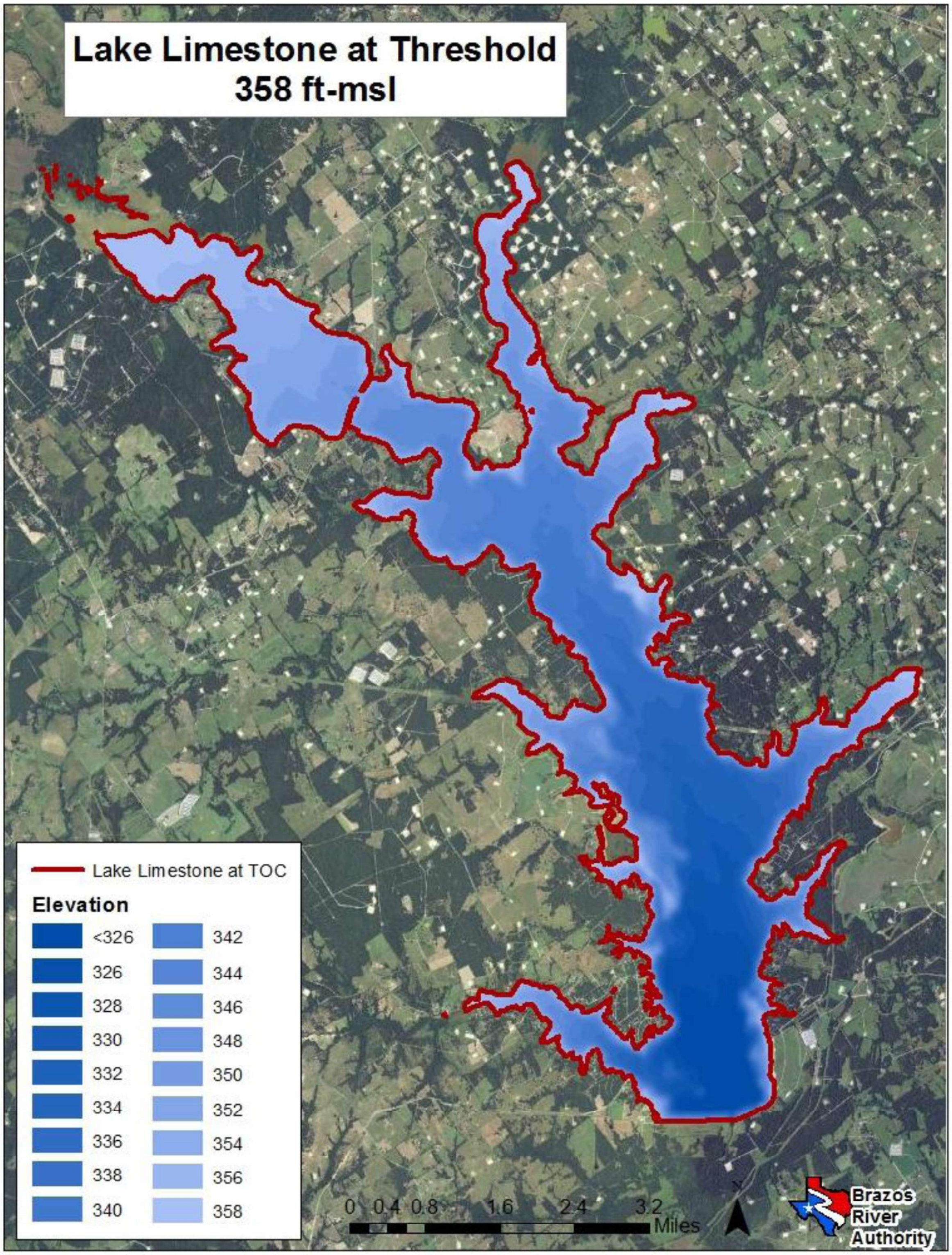

Lake Georgetown at Threshold
787 ft-msl
Lake Georgetown at TOC
Elevation
<771
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
0
0.25
0.5
1
1.5
2
Miles
Brazos
River
Authority

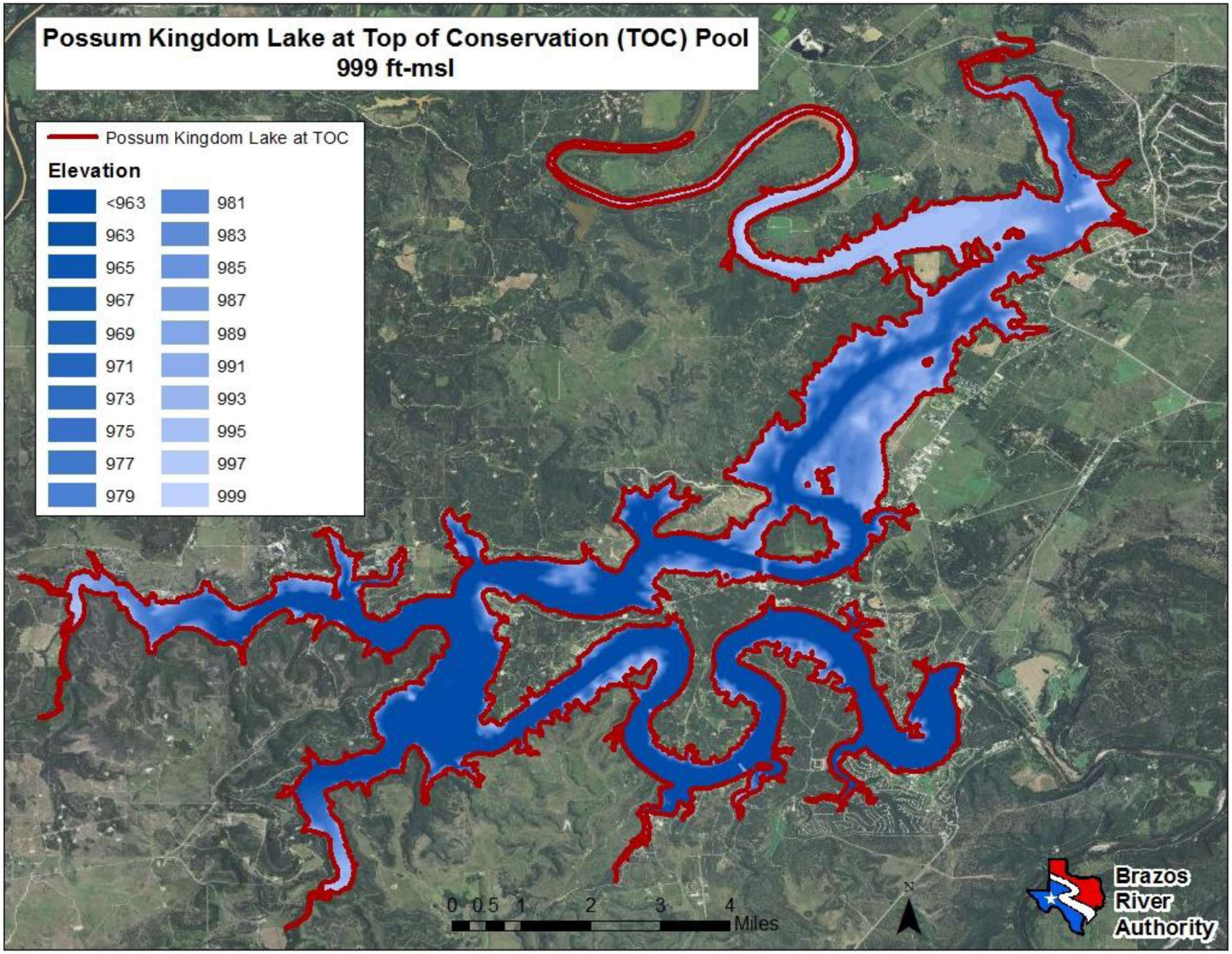

Lake Granbury at
Top of Conservation (TOC) Pool
693 ft-msl
Lake Granbury at TOC
Elevation
<658
658
660
662
664
666
668
670
672
674
676
678
680
682
684
686
688
690
692
694
N
0 0.475 0.95 1.9 2.85 3.8
Miles
Brazos
River
Authority

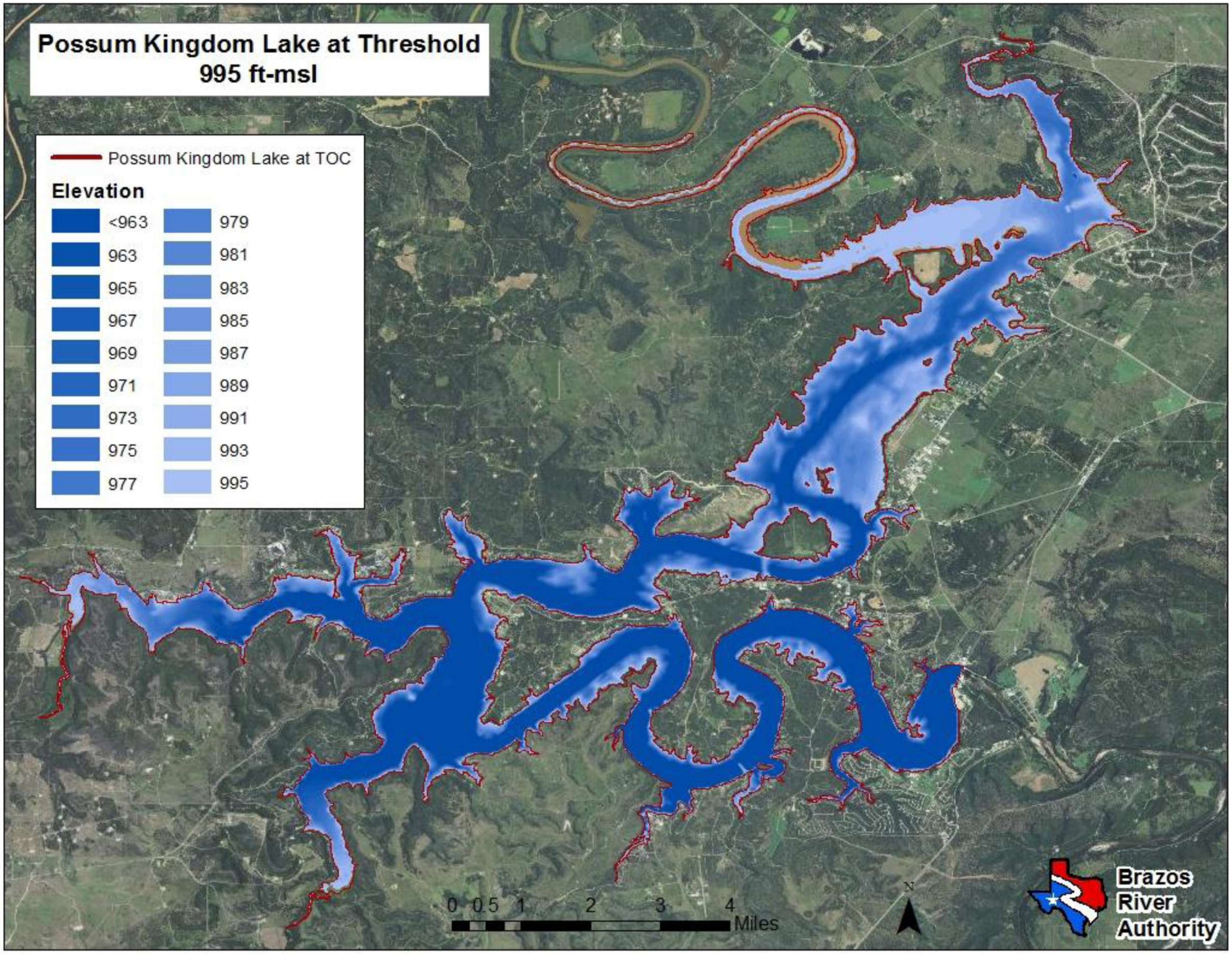

Lake Granbury at Threshold
690 ft-msl
Lake Granbury at TOC
Elevation
<658
658
660
662
664
666
668
670
672
674
676
678
680
682
684
686
688
690
0 0.5 1 2 3 4
Miles
Brazos
River
Authority

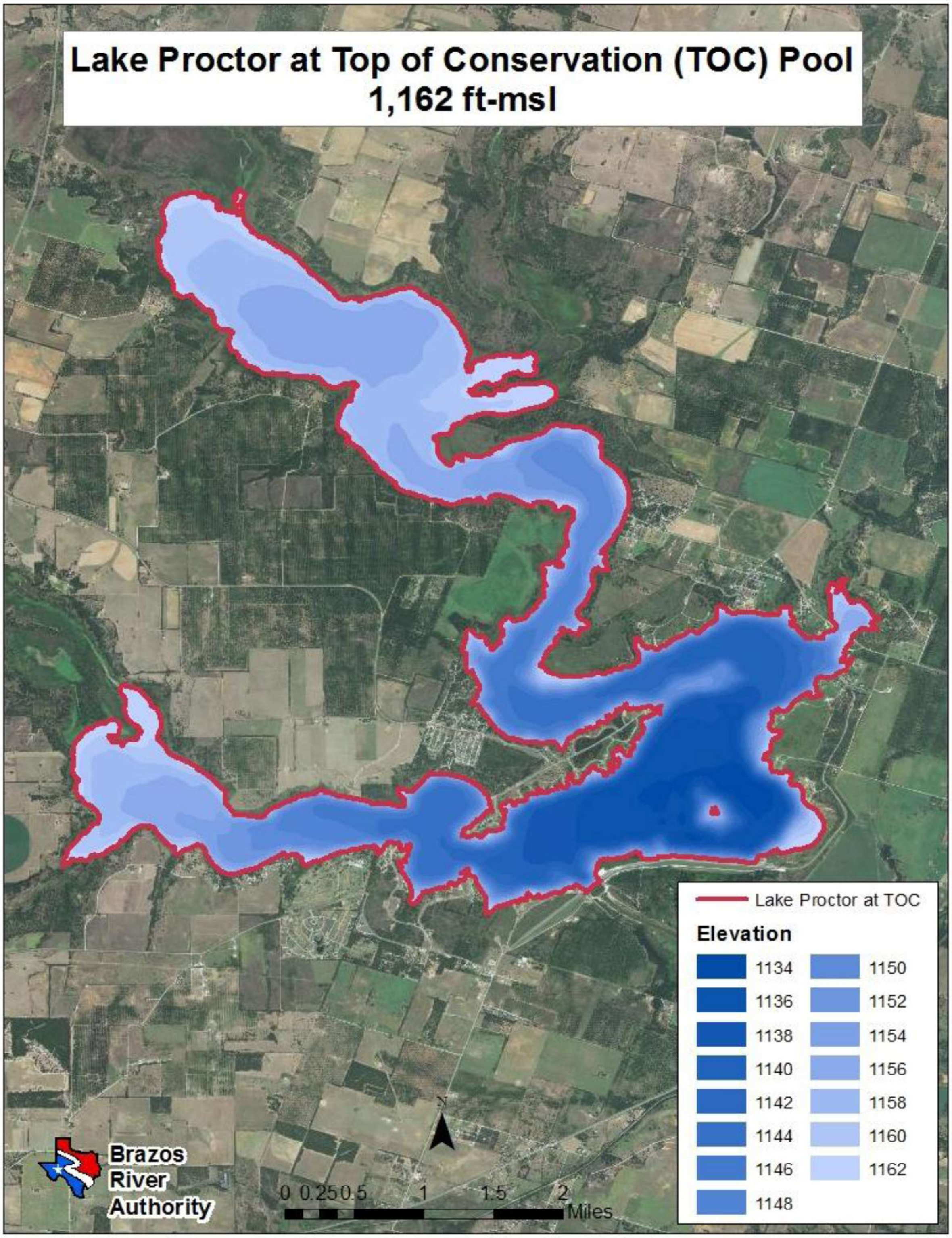

Lake Granger at Top of Conservation (TOC) Pool and Threshold
504 ft-msl
Lake Granger at TOC
Elevation
466
468
470
472
474
476
478
480
482
484
486
488
490
492
494
496
498
500
502
504
N
0 0.425 0.85 1.7 2.55 3.4
Miles
Brazos
River
Authority


Lake Limestone at Top of Conservation (TOC) Pool
363 ft-msl
Lake Limestone at TOC
Elevation
<326
326
328
330
332
334
336
338
340
342
344
346
348
350
352
354
356
358
360
362
0 0.4 0.8 1.6 2.4 3.2
Miles
N
Brazos
River
Authority

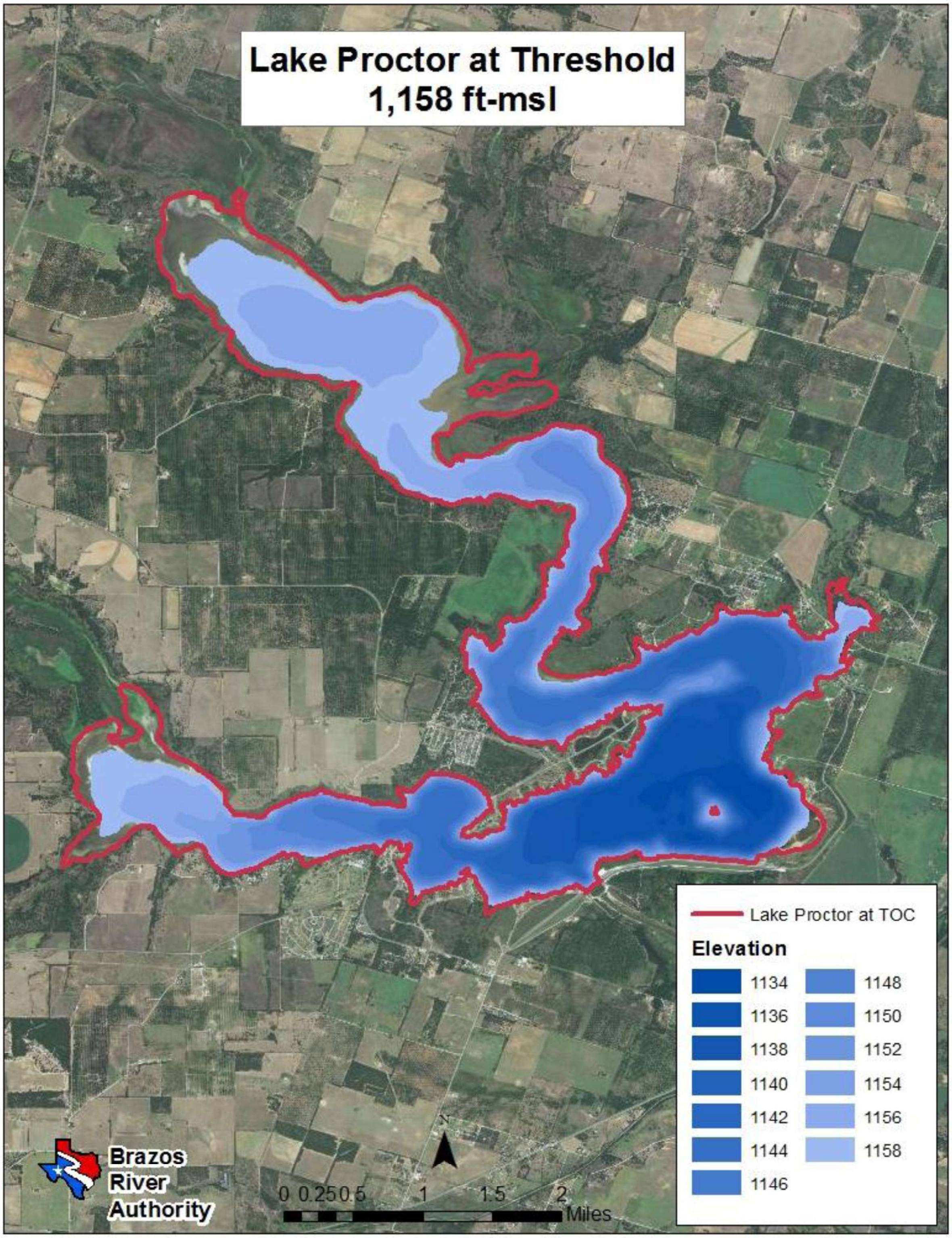

Lake Limestone at Threshold
358 ft-msl
Lake Limestone at TOC
Elevation
<326
326
328
330
332
334
336
338
340
342
344
346
348
350
352
354
356
358
0 0.4 0.8 1.6 2.4 3.2
Miles
N
Brazos
River
Authority


Possum Kingdom Lake at Top of Conservation (TOC) Pool
999 ft-msl
Possum Kingdom Lake at TOC
Elevation
<963
963
965
967
969
971
973
975
977
979
981
983
985
987
989
991
993
995
997
999
0 0.5 1 2 3 4
Miles
N
Brazos
River
Authority

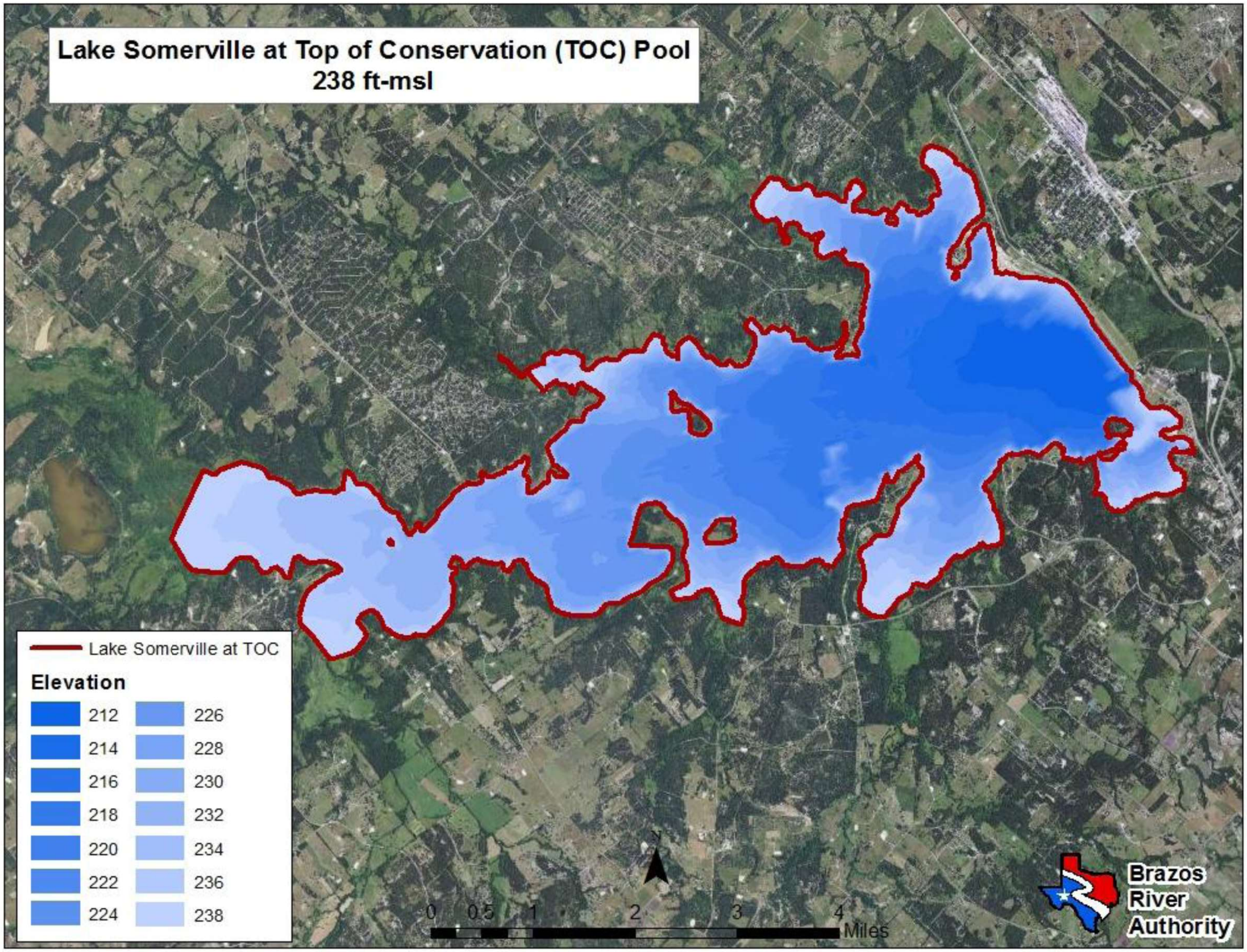

Possum Kingdom Lake at Threshold
995 ft-msl
Possum Kingdom Lake at TOC
Elevation
<963
963
965
967
969
971
973
975
977
979
981
983
985
987
989
991
993
995
0 0.5 1 2 3 4
Miles
N
Brazos
River
Authority



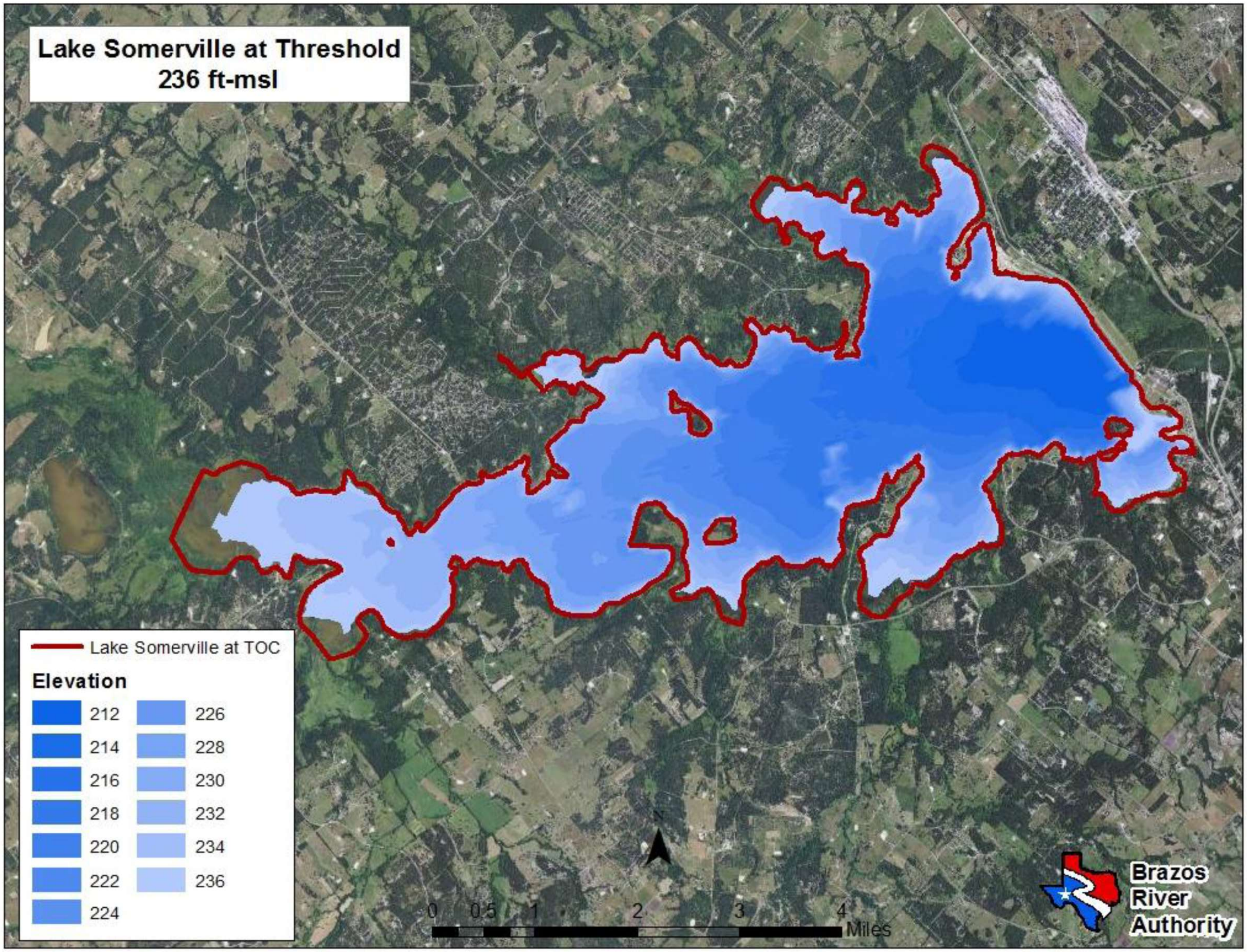
Lake Proctor at Top of Conservation (TOC) Pool
1,162 ft-msl
Lake Proctor at TOC
Elevation
1134
1136
1138
1140
1142
1144
1146
1148
1150
1152
1154
1156
1158
1160
1162
Brazos
River
Authority
0 0.25 0.5 1 1.5 2
Miles

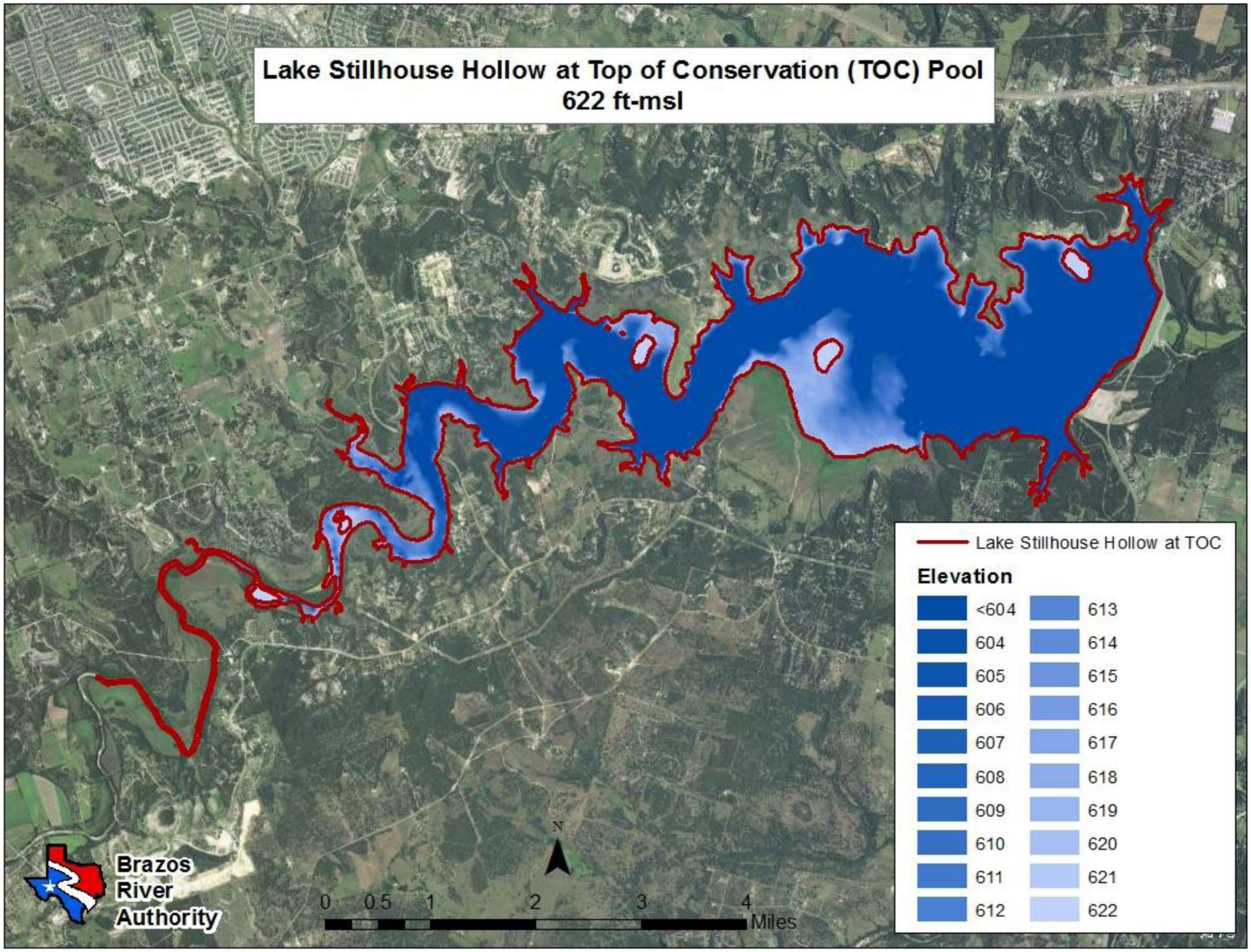


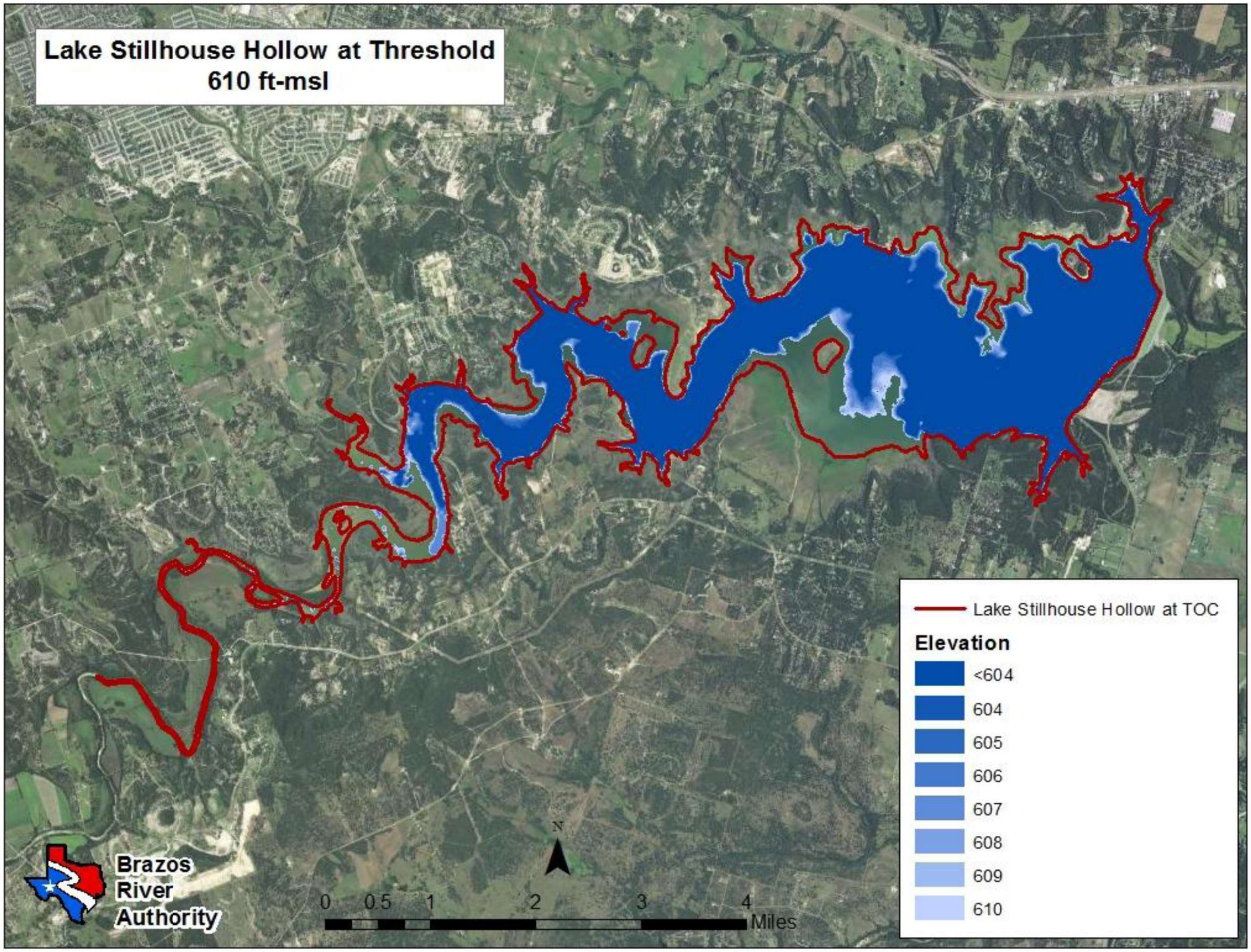
Lake Proctor at Threshold
1,158 ft-msl
Lake Proctor at TOC
Elevation
1134
1136
1138
1140
1142
1144
1146
1148
1150
1152
1154
1156
1158
Brazos
River
Authority
0 0.25 0.5 1 1.5 2
Miles
N



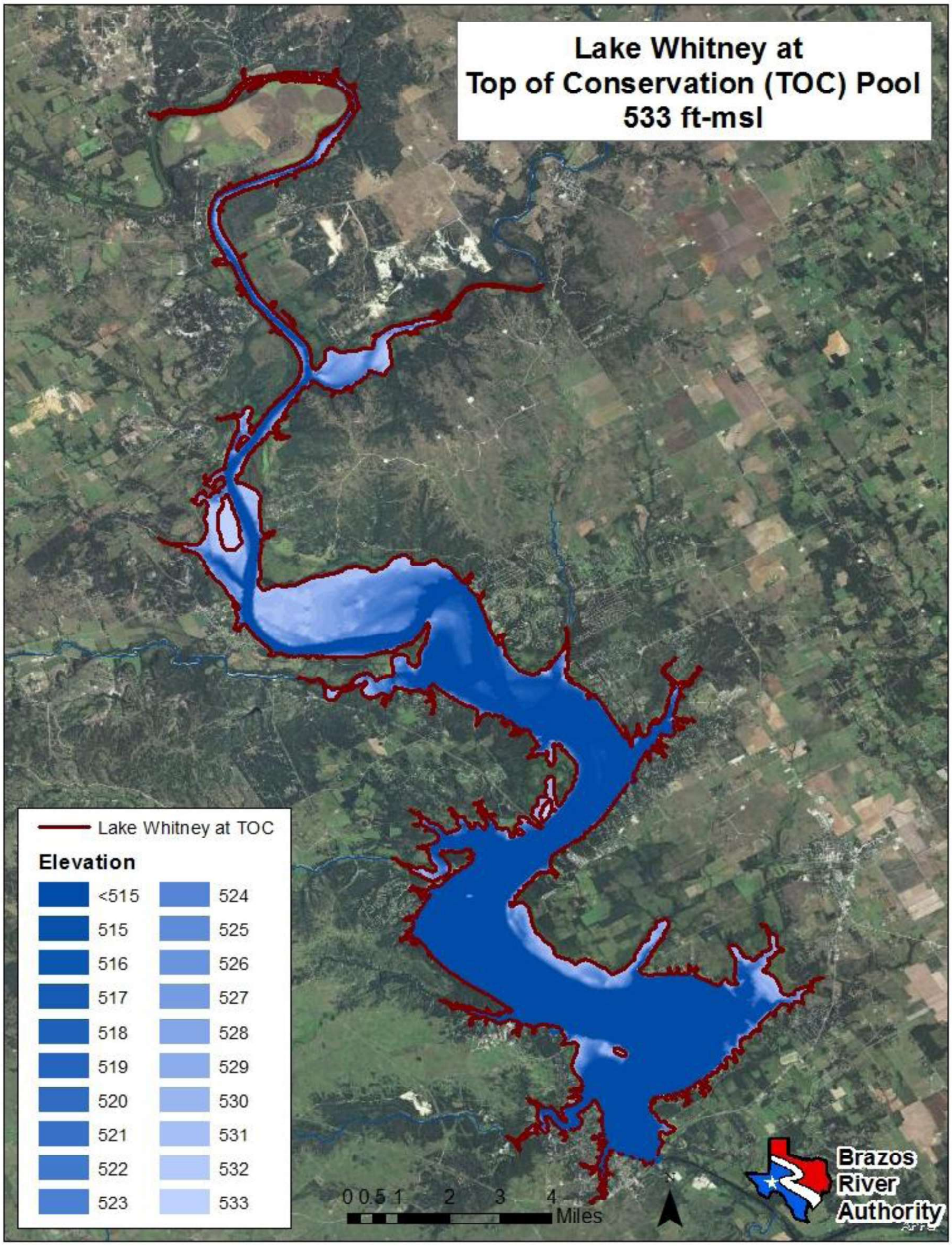
Lake Somerville at Top of Conservation (TOC) Pool
238 ft-msl
Lake Somerville at TOC
Elevation
212
214
216
218
220
222
224
226
228
230
232
234
236
238
N
0
0.5
1
2
3
4
Miles
Brazos
River
Authority


Lake Somerville at Threshold
236 ft-msl
Lake Somerville at TOC
Elevation
212
214
216
218
220
222
224
226
228
230
232
234
236
N
0 0.5 1 2 3 4
Miles
Brazos
River
Authority

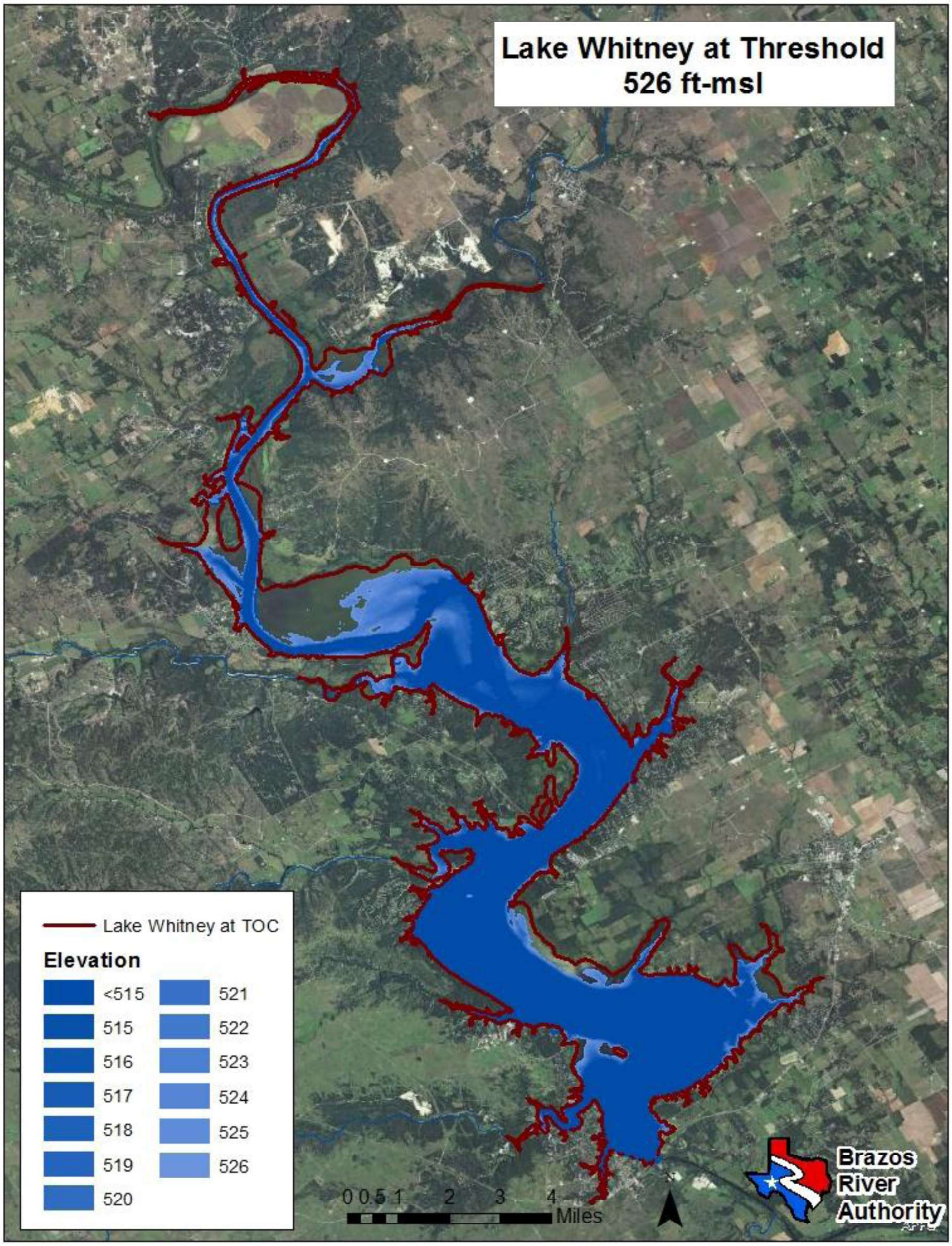

Lake Stillhouse Hollow at Top of Conservation (TOC) Pool
622 ft-msl
Lake Stillhouse Hollow at TOC
Elevation
<604
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
N
0
0.5
1
2
3
4
Miles
Brazos
River
Authority



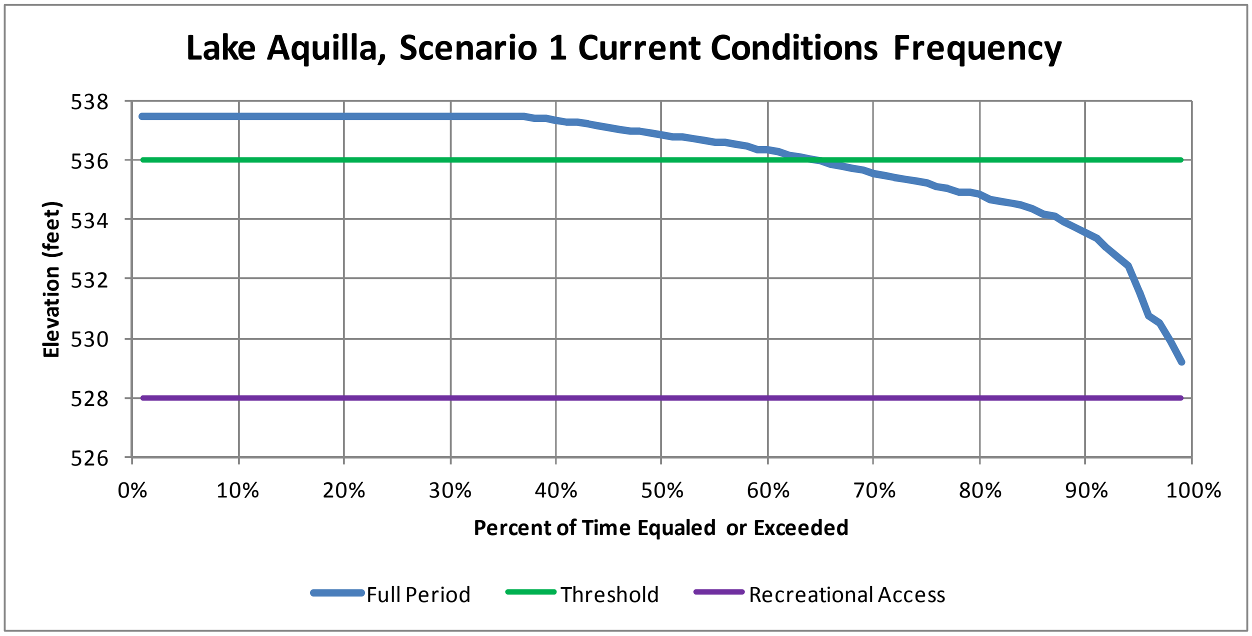
Lake Stillhouse Hollow at Threshold
610 ft-msl
Lake Stillhouse Hollow at TOC
Elevation
<604
604
605
606
607
608
609
610
N
0
0.5
1
2
3
4
Miles
Brazos
River
Authority

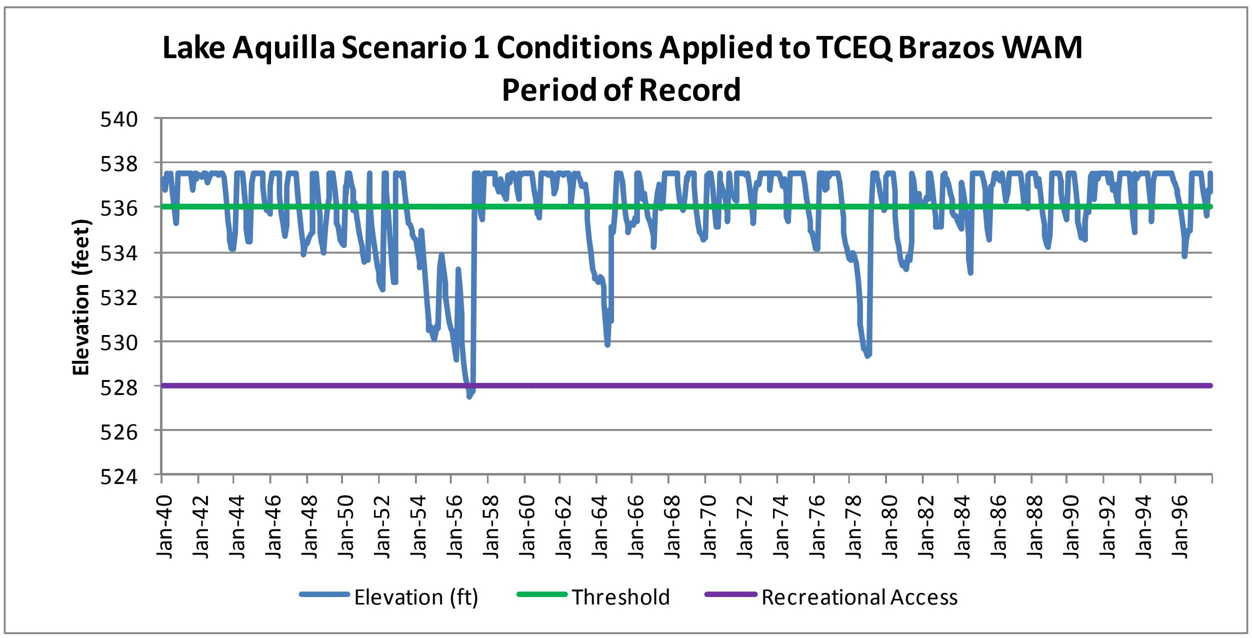


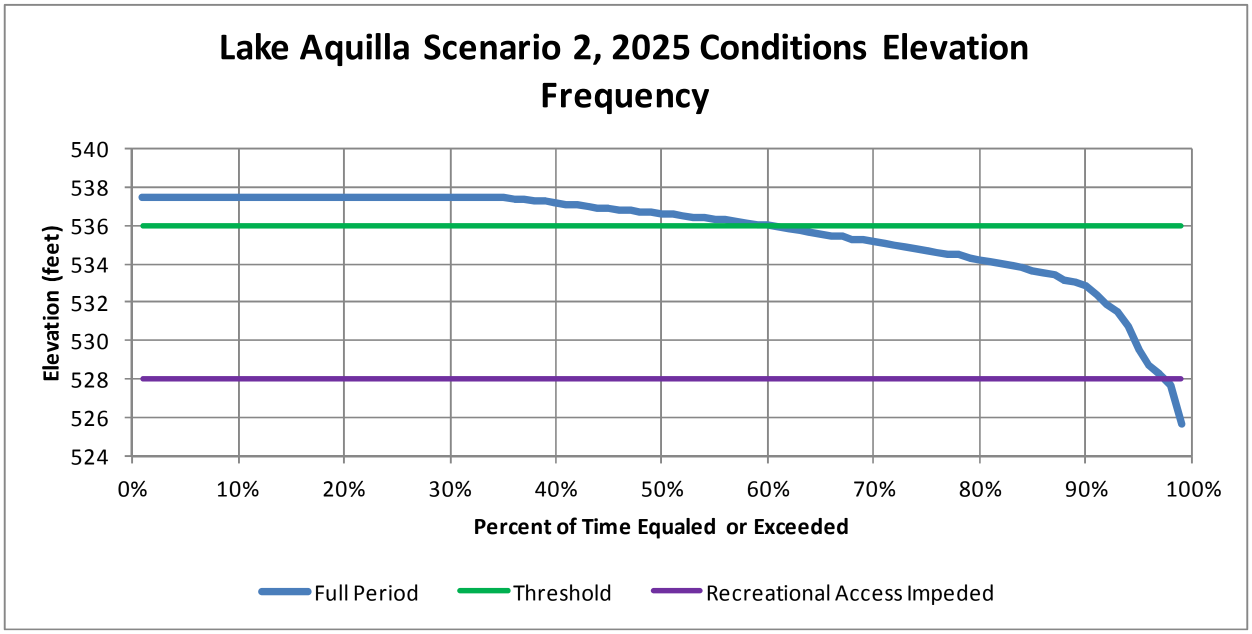
Lake Whitney at
Top of Conservation (TOC) Pool
533 ft-msl
Lake Whitney at TOC
Elevation
<515
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
0 0.5 1 2 3 4
Miles
Brazos
River
Authority

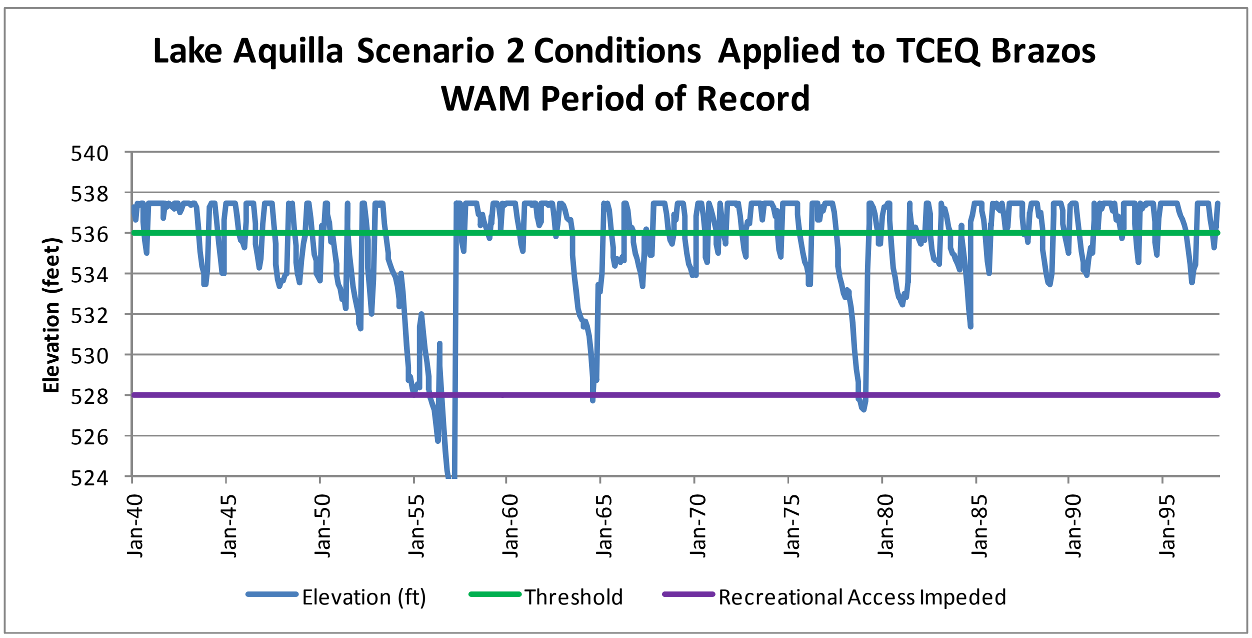

Lake Whitney at Threshold
526 ft-msl
Lake Whitney at TOC
Elevation
<515
515
516
517
518
519
520
521
522
523
524
525
526
0 0.5 1 2 3 4
Miles
Brazos
River
Authority

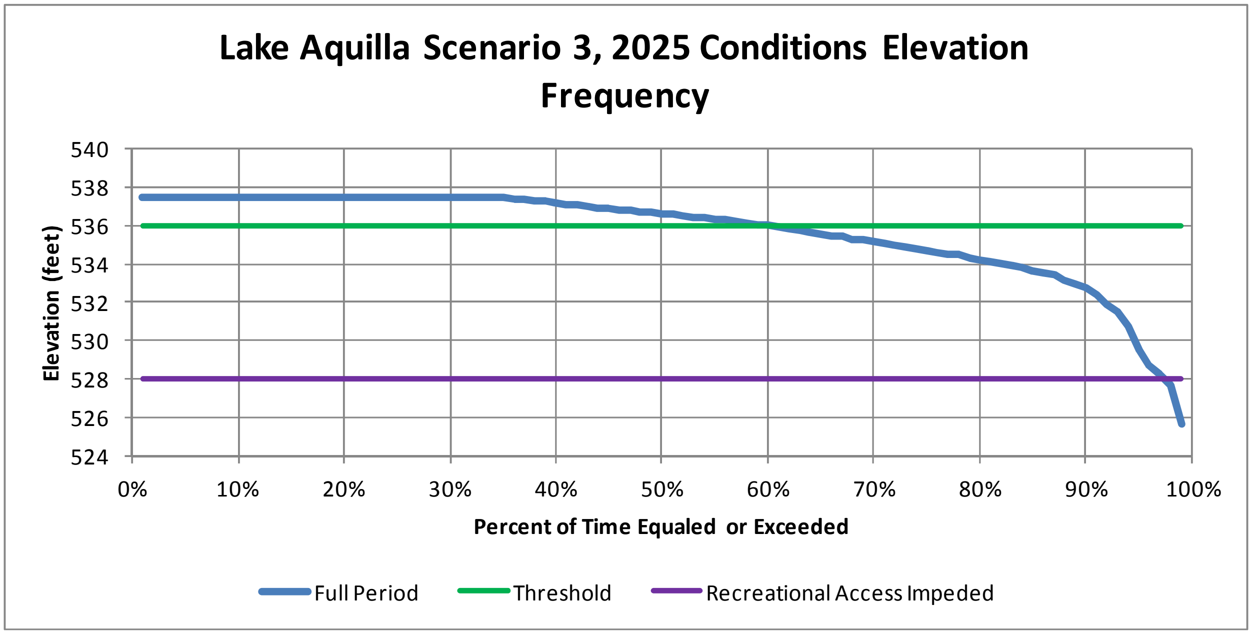
# Appendix D
# Water Availability Modeling Results by Reservoir

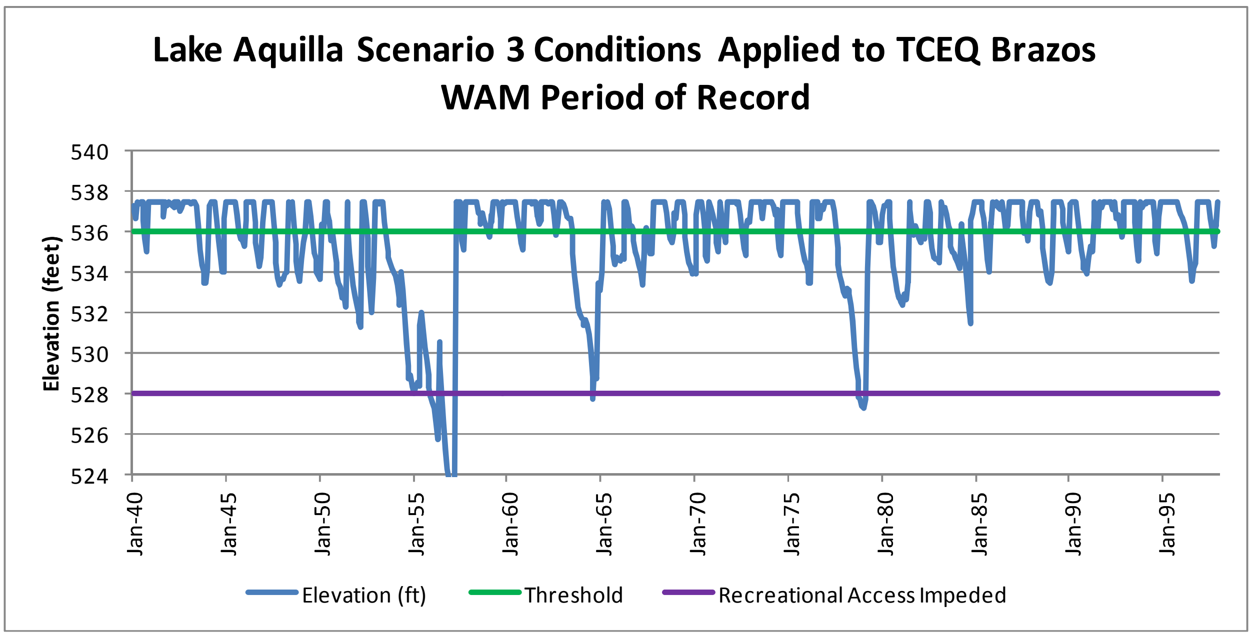

Lake Aquilla, Scenario 1 Current Conditions Frequency
Elevation (feet)
538
536
534
532
530
528
526
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access

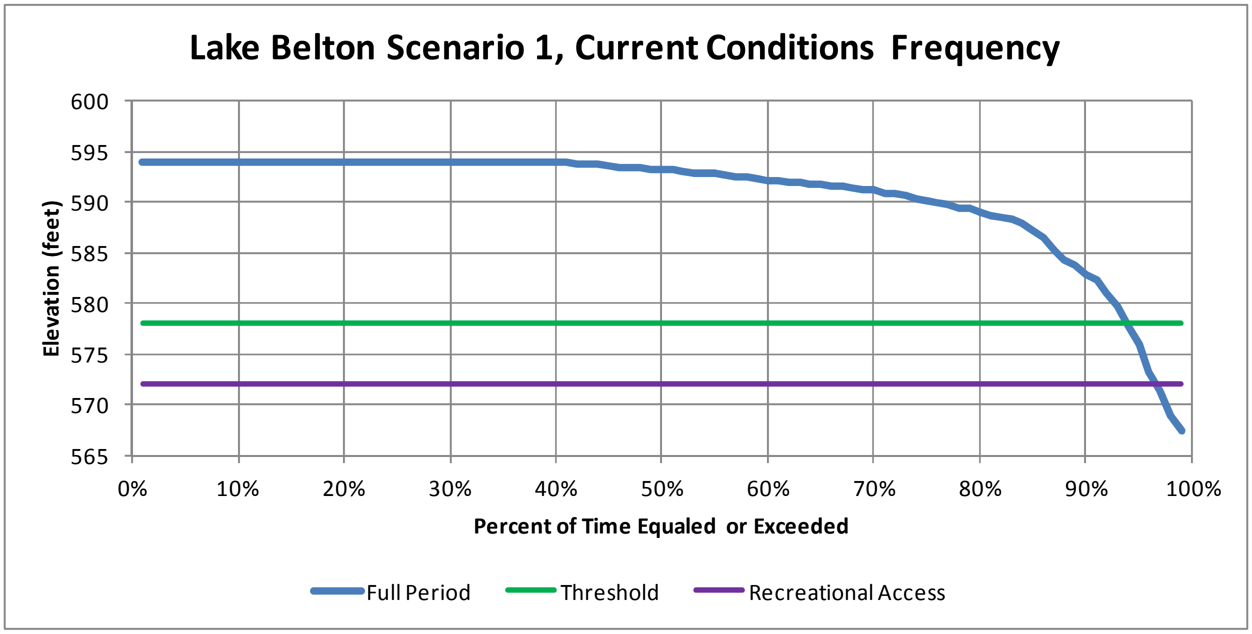

Lake Aquilla Scenario 1 Conditions Applied to TCEQ Brazos WAM Period of Record
Elevation (feet)
540
538
536
534
532
530
528
526
524
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Elevation (ft)
Threshold
Recreational Access


Lake Aquilla Scenario 2, 2025 Conditions Elevation Frequency
540
538
536
534
532
530
528
526
524
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access Impeded

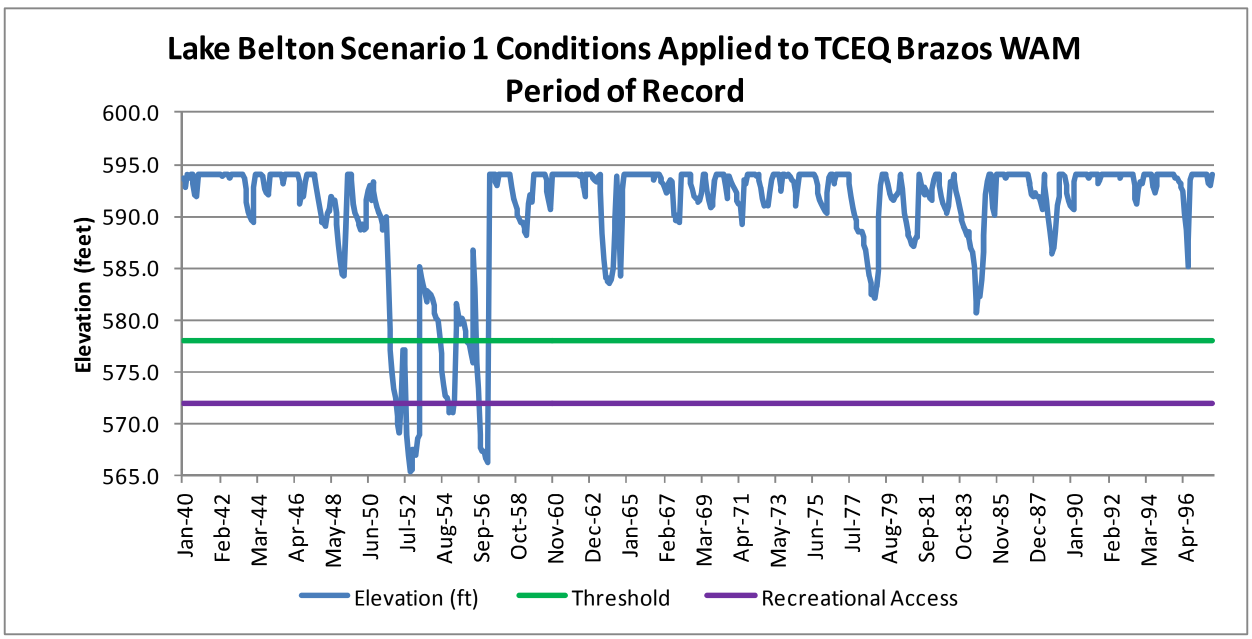

Lake Aquilla Scenario 2 Conditions Applied to TCEQ Brazos WAM Period of Record
540
538
536
534
532
530
528
526
524
Elevation (feet)
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Elevation (ft)
Threshold
Recreational Access Impeded


Lake Aquilla Scenario 3, 2025 Conditions Elevation Frequency
540
538
536
534
532
530
528
526
524
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access Impeded

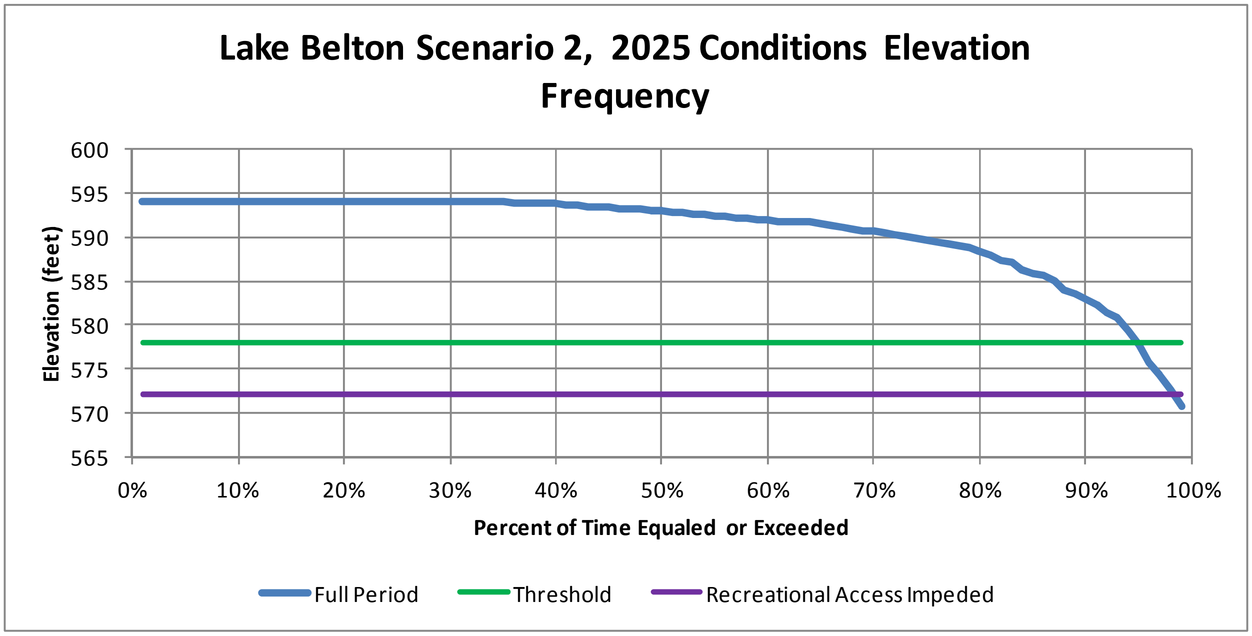

Lake Aquilla Scenario 3 Conditions Applied to TCEQ Brazos WAM Period of Record
540
538
536
534
532
530
528
526
524
Elevation (feet)
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Elevation (ft)
Threshold
Recreational Access Impeded



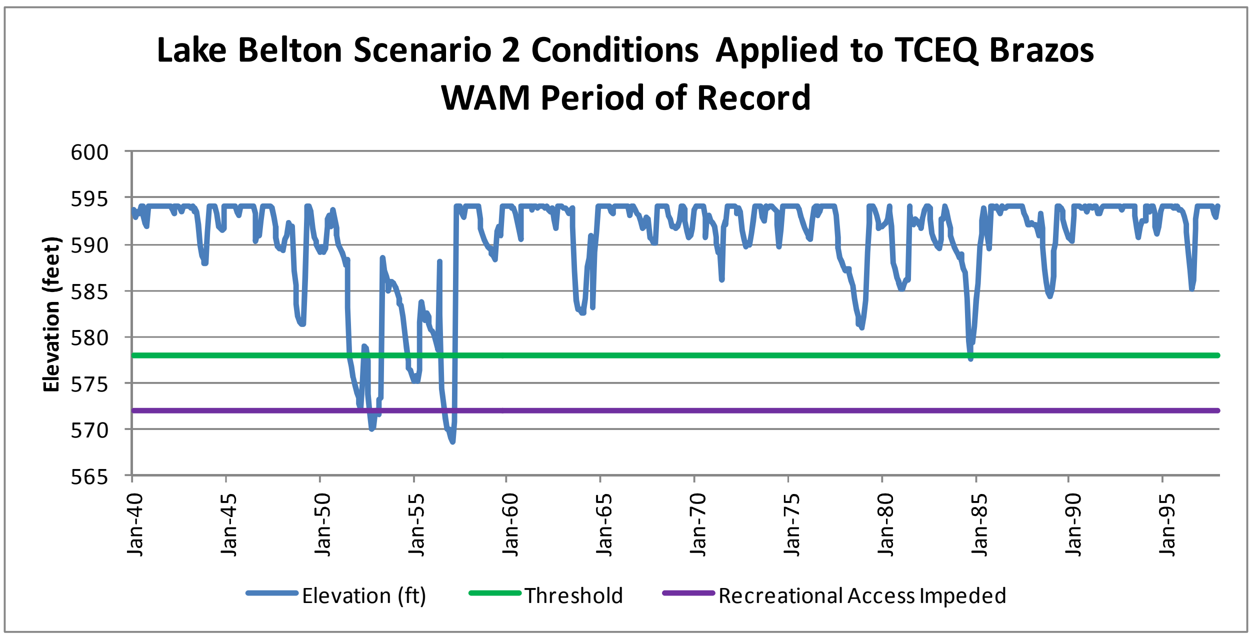
Lake Belton Scenario 1, Current Conditions Frequency
600
595
590
585
580
575
570
565
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access

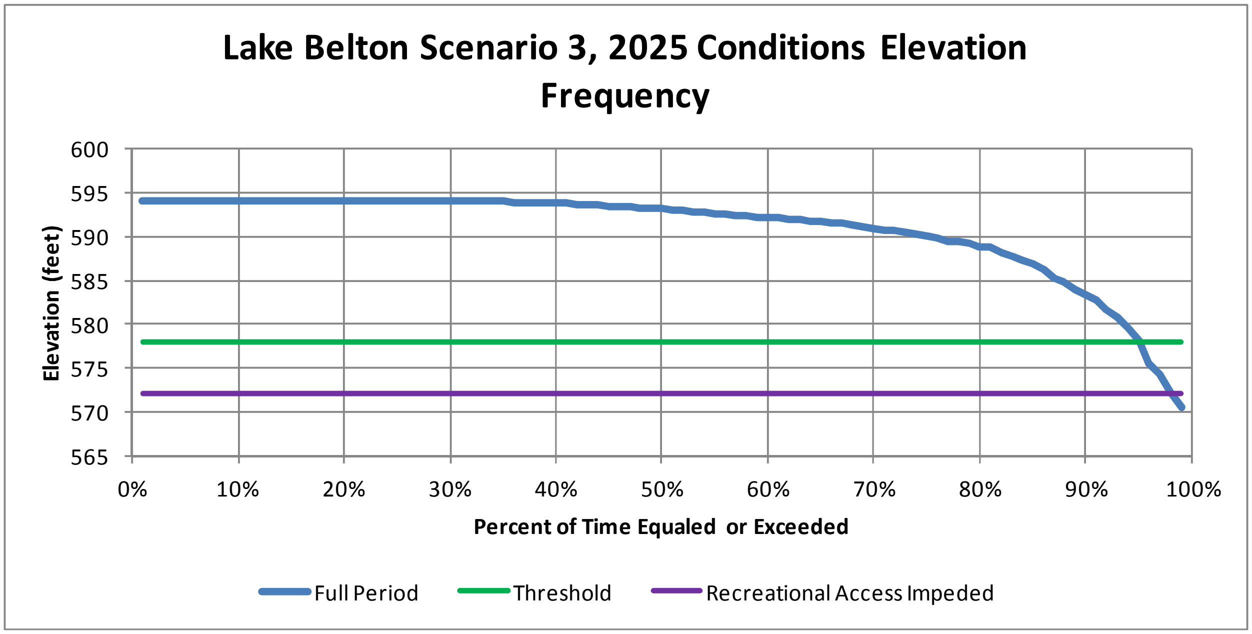
Lake Belton Scenario 1 Conditions Applied to TCEQ Brazos WAM
Period of Record
600.0
595.0
590.0
585.0
580.0
575.0
570.0
565.0
Elevation (feet)
Jan-40
Feb-42
Mar-44
Apr-46
May-48
Jun-50
Jul-52
Aug-54
Sep-56
Oct-58
Nov-60
Dec-62
Jan-65
Feb-67
Mar-69
Apr-71
May-73
Jun-75
Jul-77
Aug-79
Sep-81
Oct-83
Nov-85
Dec-87
Jan-90
Feb-92
Mar-94
Apr-96
Elevation (ft)
Threshold
Recreational Access

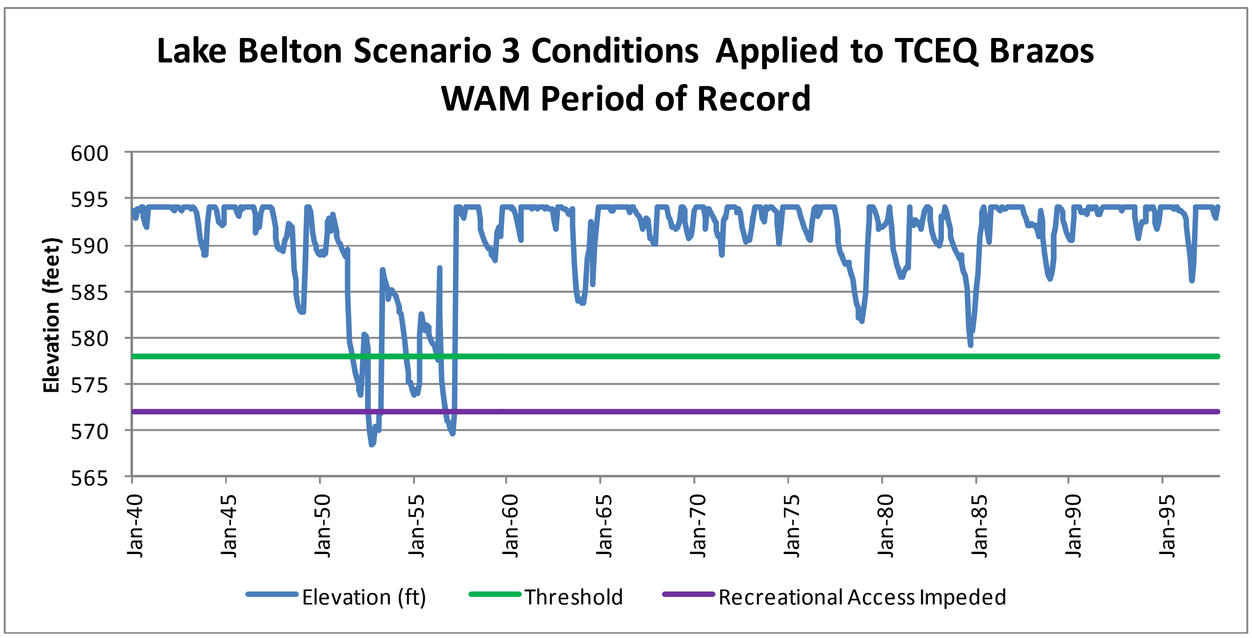


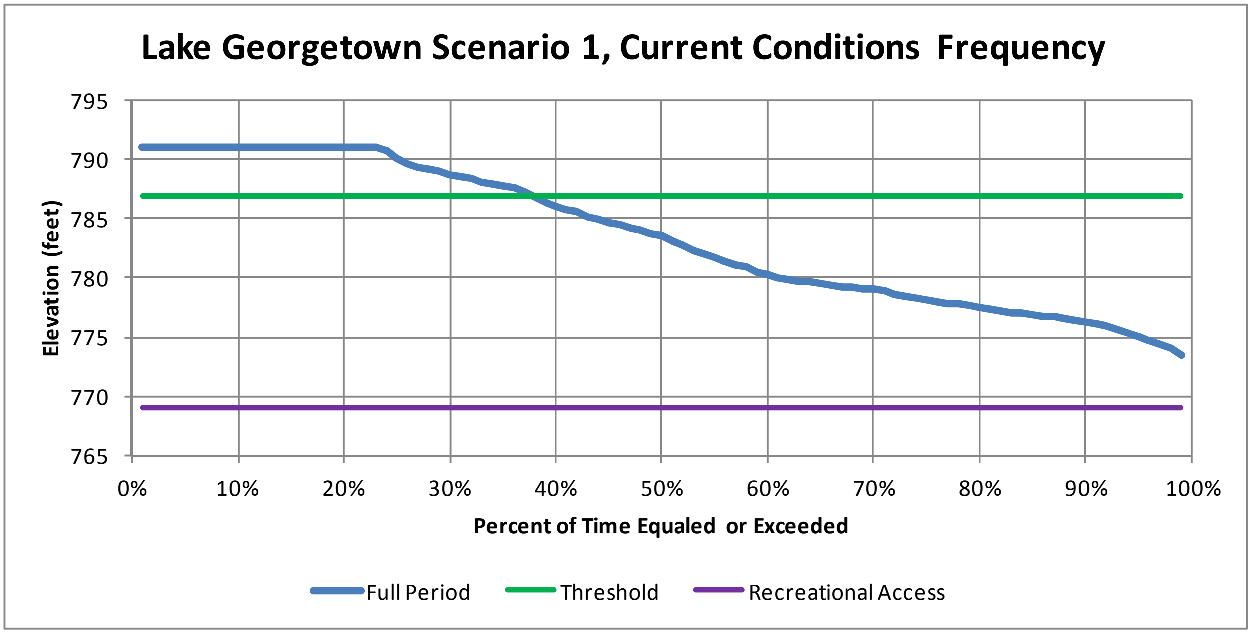
Lake Belton Scenario 2, 2025 Conditions Elevation Frequency
600
595
590
585
580
575
570
565
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access Impeded

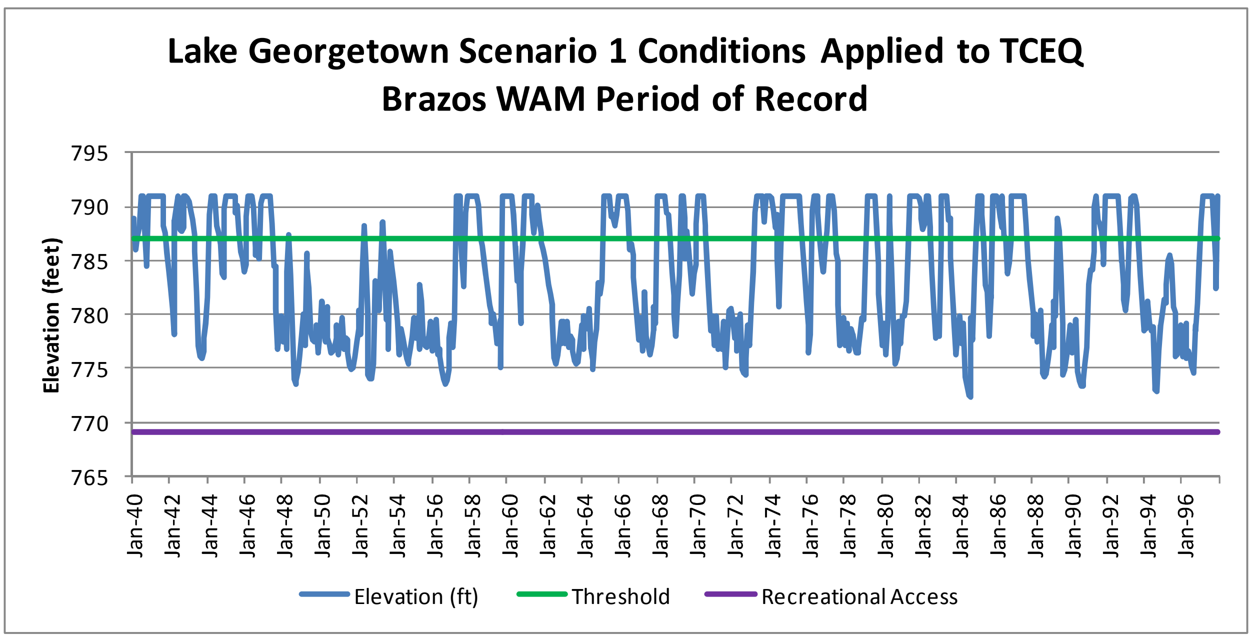



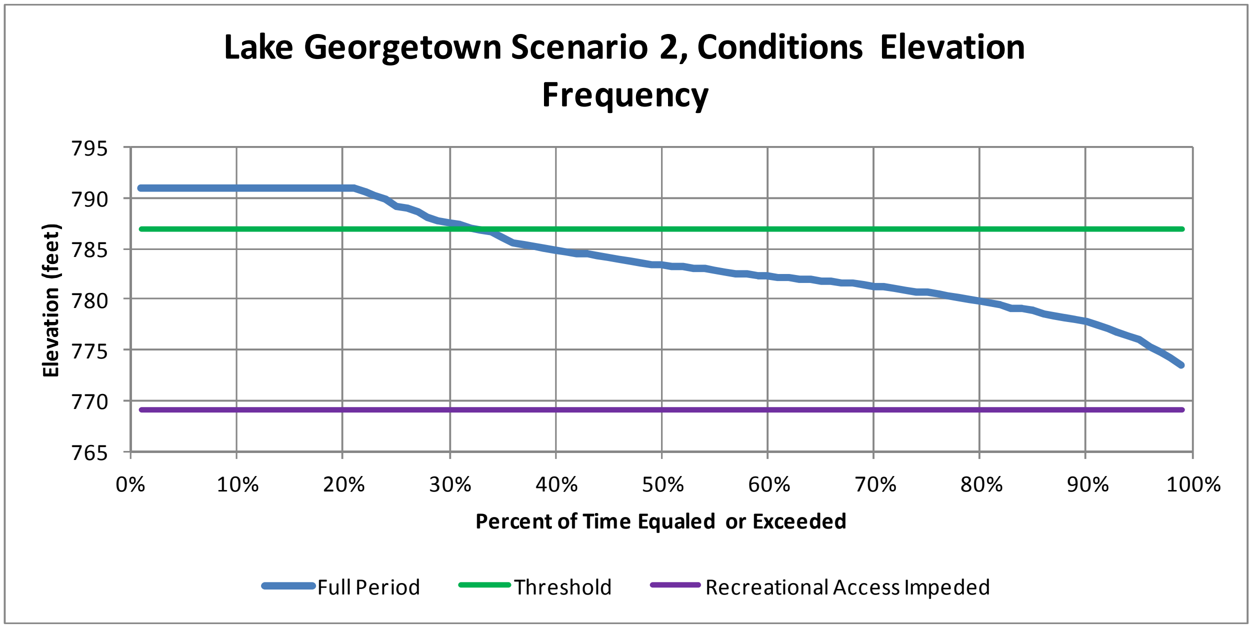
Lake Belton Scenario 2 Conditions Applied to TCEQ Brazos WAM Period of Record
600
595
590
585
580
575
570
565
Elevation (feet)
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Elevation (ft)
Threshold
Recreational Access Impeded


Lake Belton Scenario 3, 2025 Conditions Elevation Frequency
600
595
590
585
580
575
570
565
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access Impeded

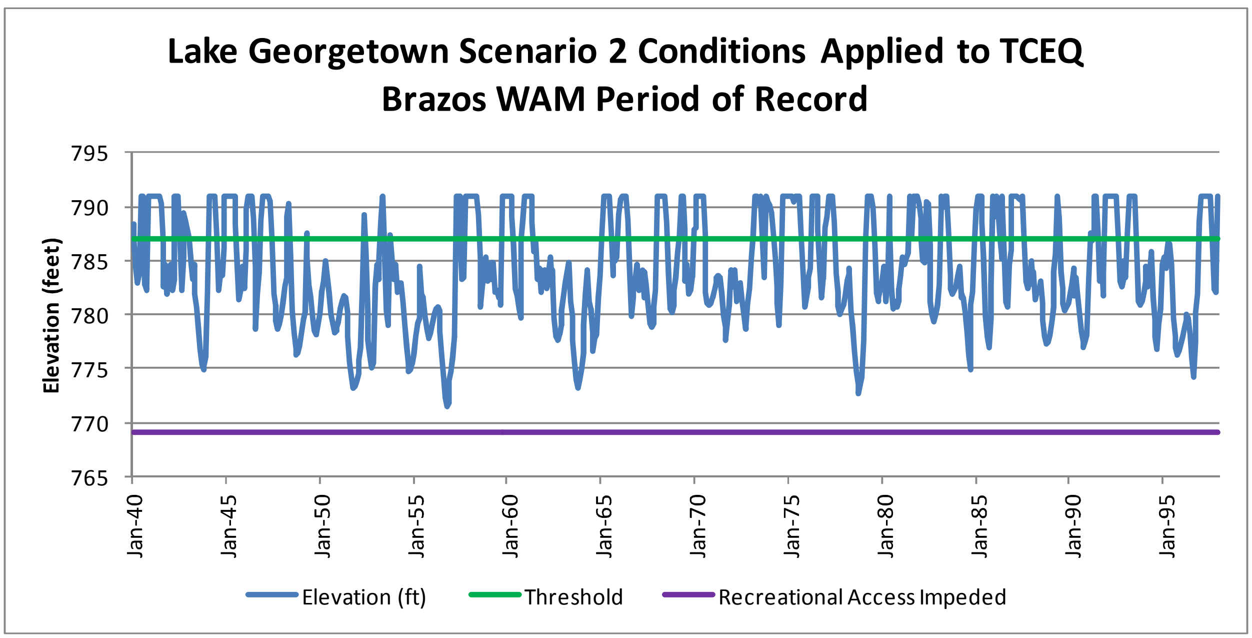

Lake Belton Scenario 3 Conditions Applied to TCEQ Brazos WAM Period of Record
600
595
590
585
580
575
570
565
Elevation (feet)
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Elevation (ft)
Threshold
Recreational Access Impeded


Lake Georgetown Scenario 1, Current Conditions Frequency
Elevation (feet)
795
790
785
780
775
770
765
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access

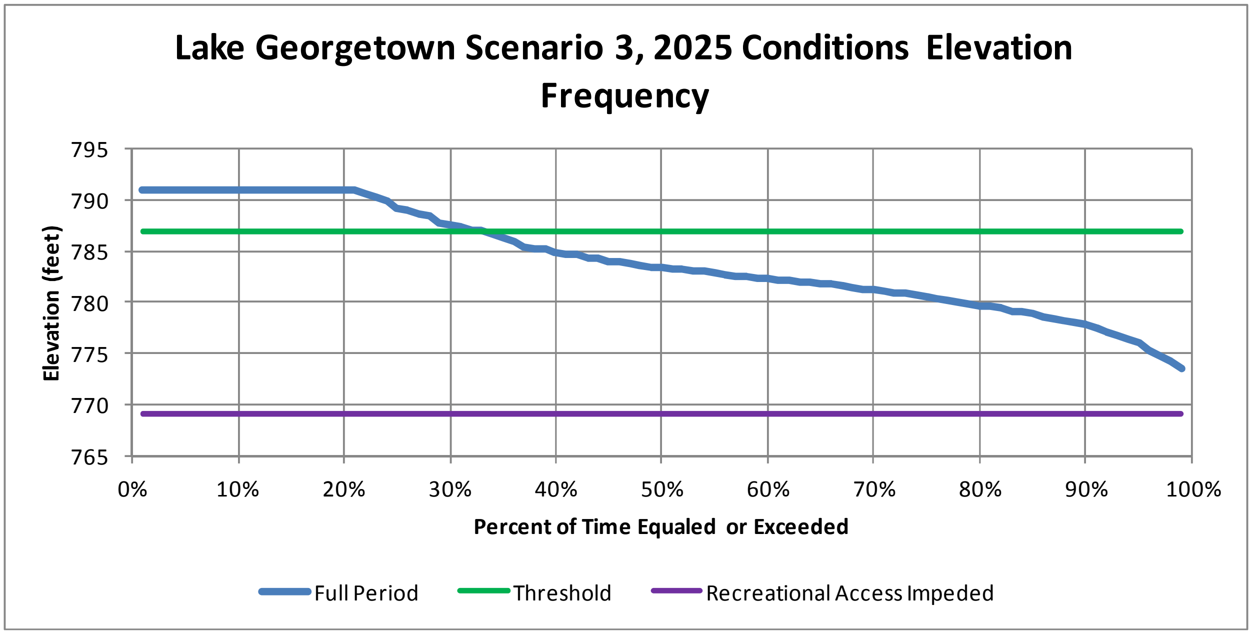

Lake Georgetown Scenario 1 Conditions Applied to TCEQ Brazos WAM Period of Record
Elevation (feet)
795
790
785
780
775
770
765
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Elevation (ft)
Threshold
Recreational Access

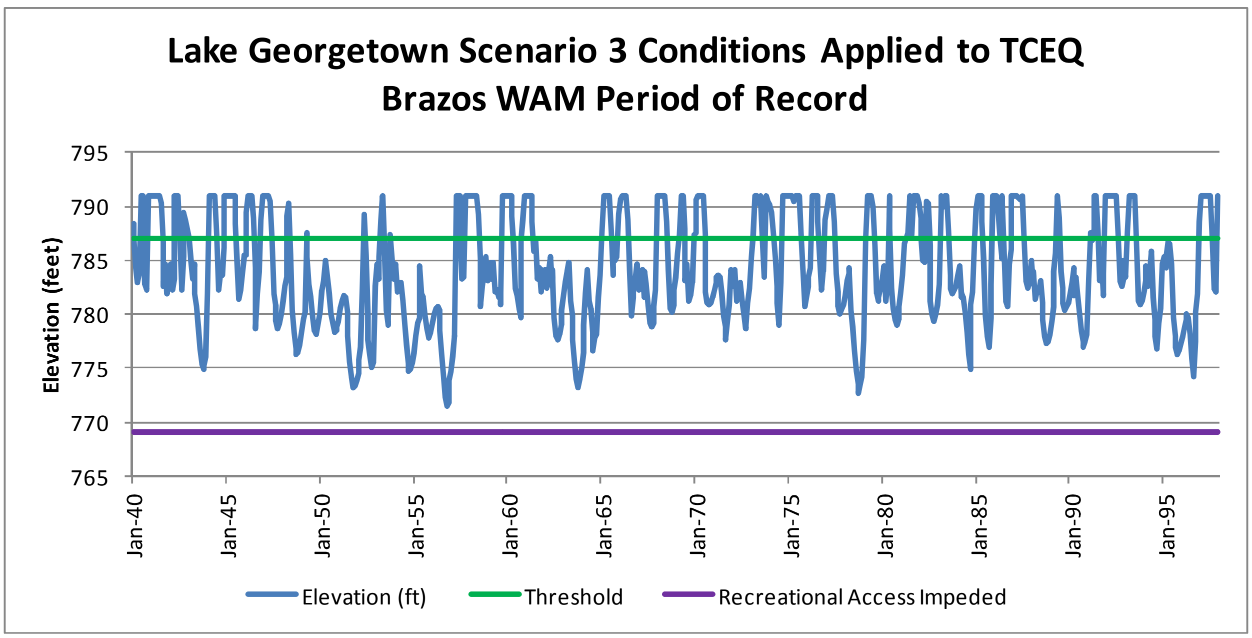


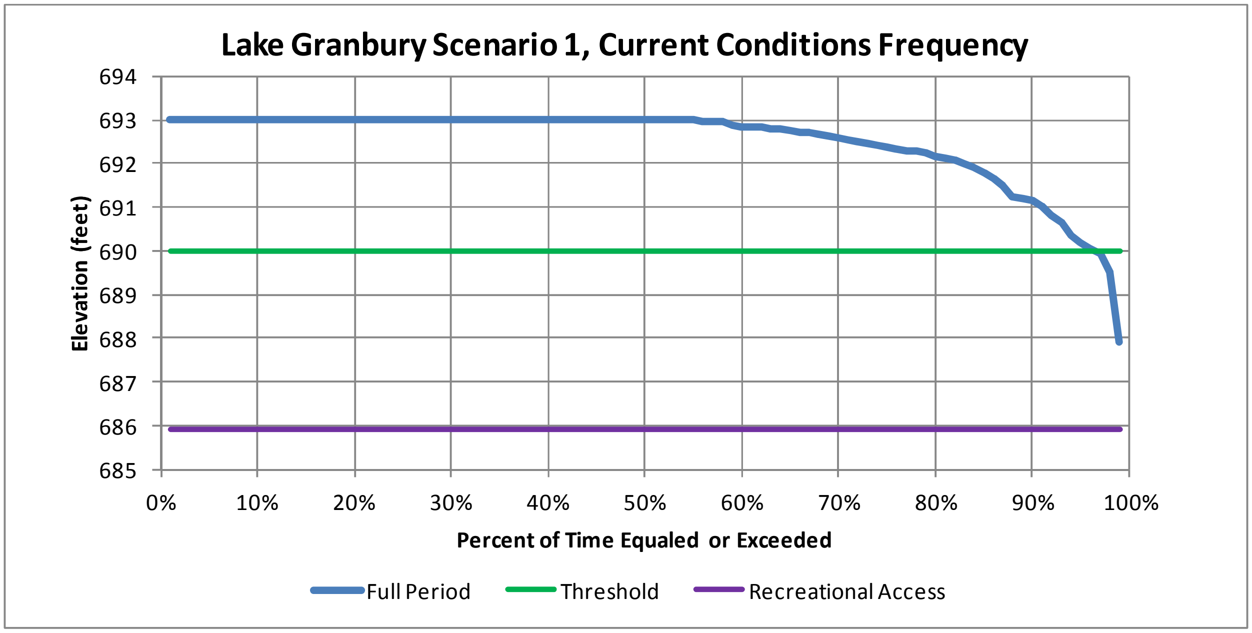
Lake Georgetown Scenario 2, Conditions Elevation Frequency
Elevation (feet)
795
790
785
780
775
770
765
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access Impeded

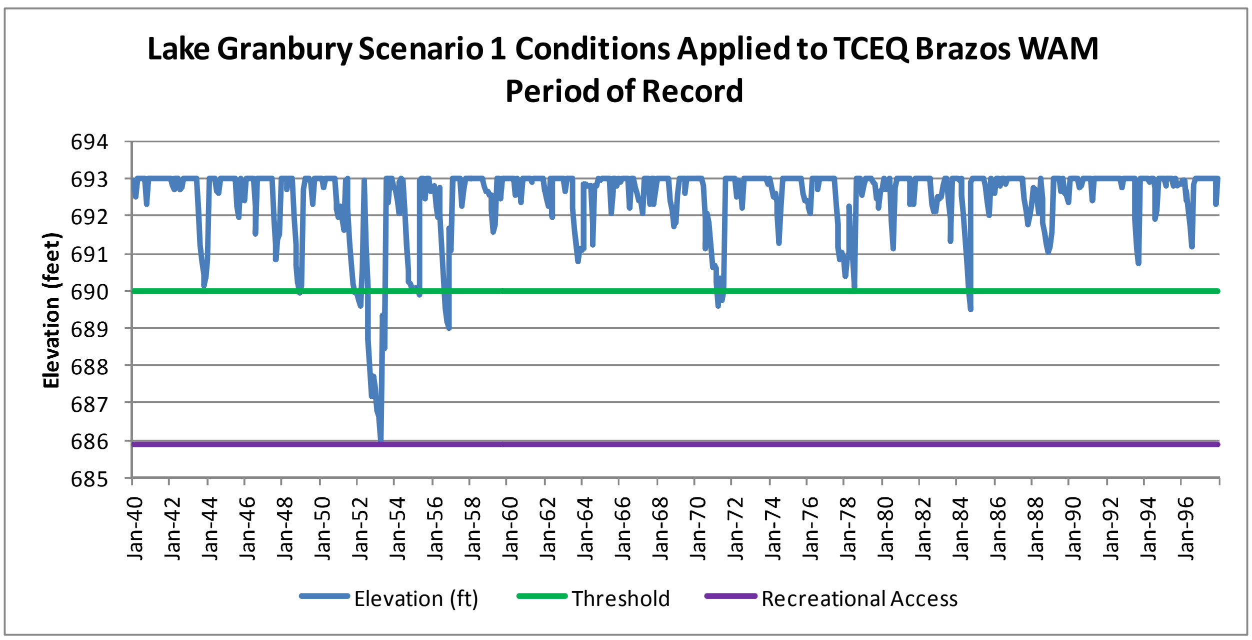



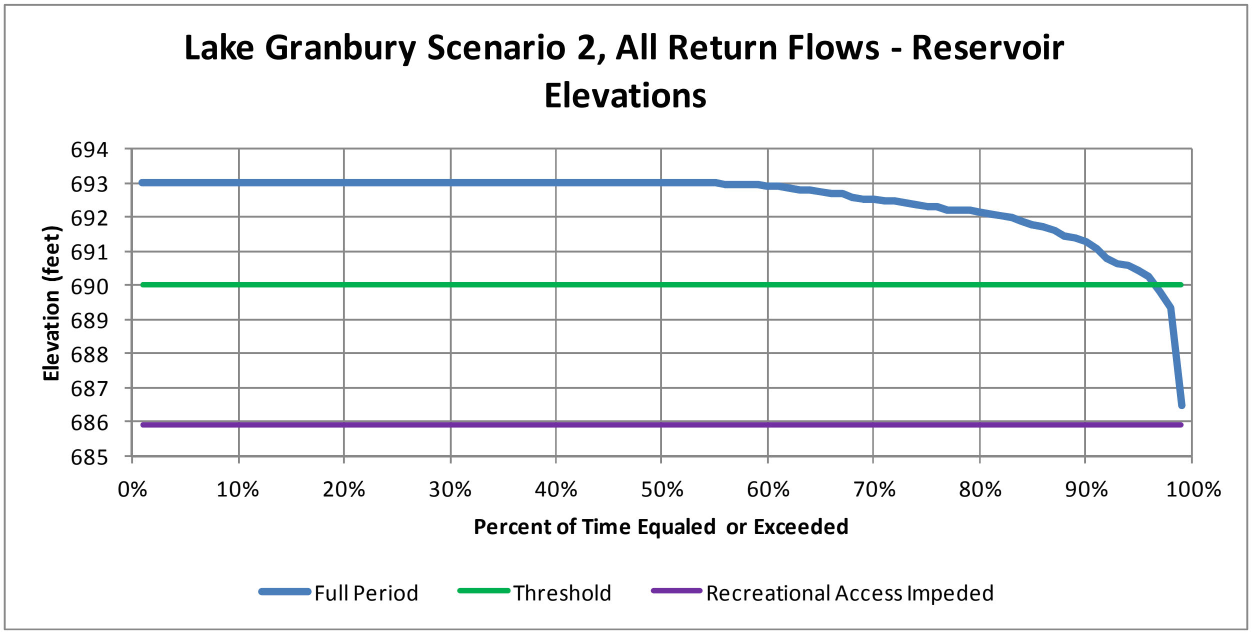
Lake Georgetown Scenario 2 Conditions Applied to TCEQ Brazos WAM Period of Record
Elevation (feet)
795
790
785
780
775
770
765
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Elevation (ft)
Threshold
Recreational Access Impeded

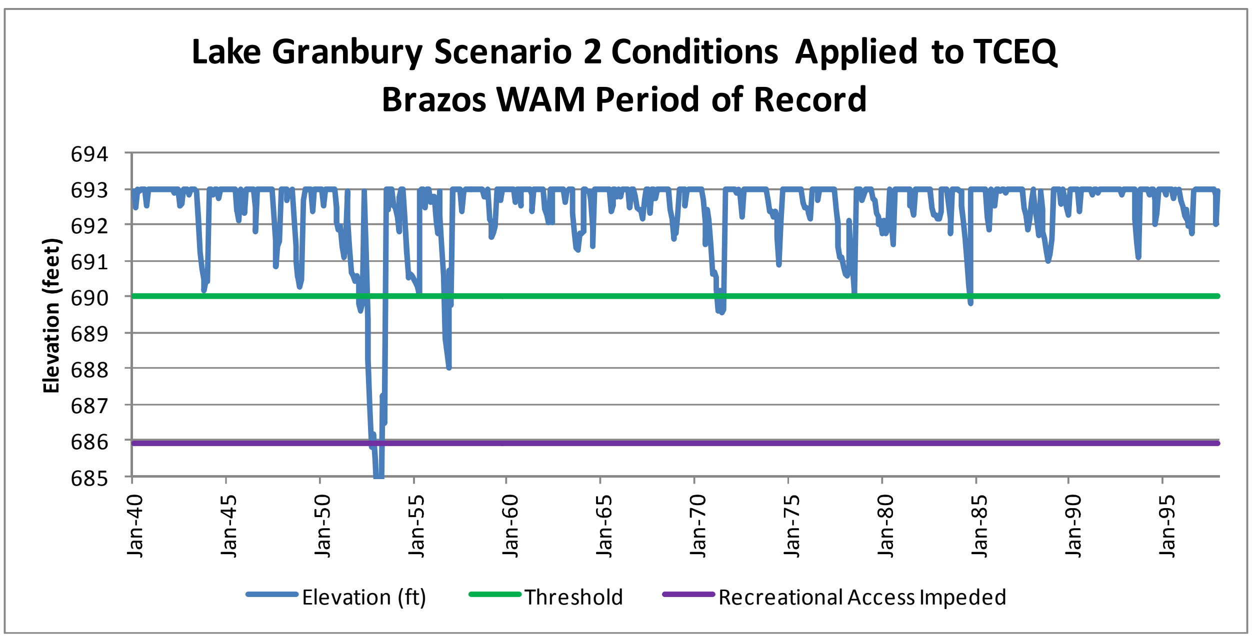

Lake Georgetown Scenario 3, 2025 Conditions Elevation Frequency
795
790
785
780
775
770
765
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access Impeded

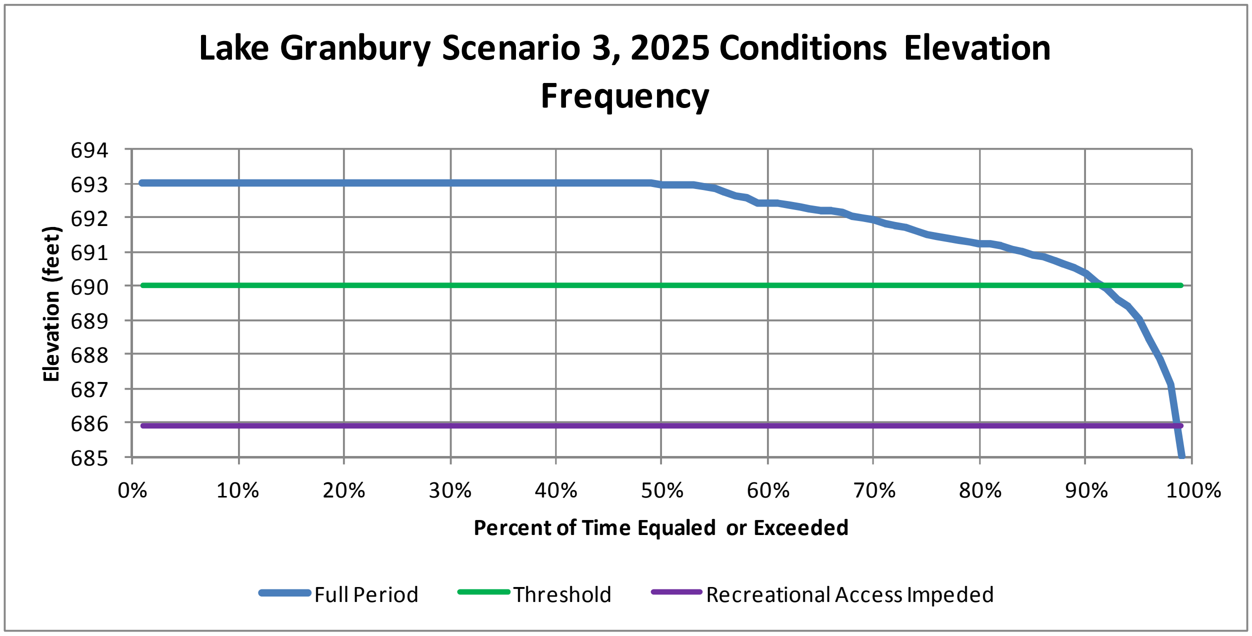

Lake Georgetown Scenario 3 Conditions Applied to TCEQ Brazos WAM Period of Record
795
790
785
780
775
770
765
Elevation (feet)
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Elevation (ft)
Threshold
Recreational Access Impeded

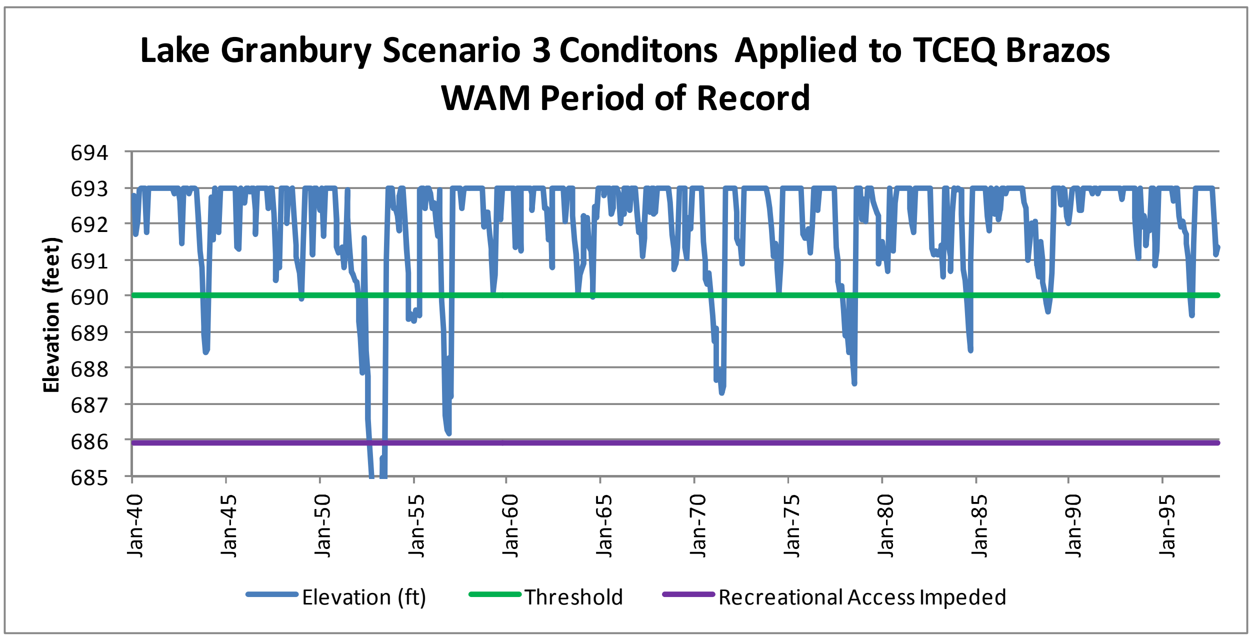

Lake Granbury Scenario 1, Current Conditions Frequency
694
693
692
691
690
689
688
687
686
685
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access

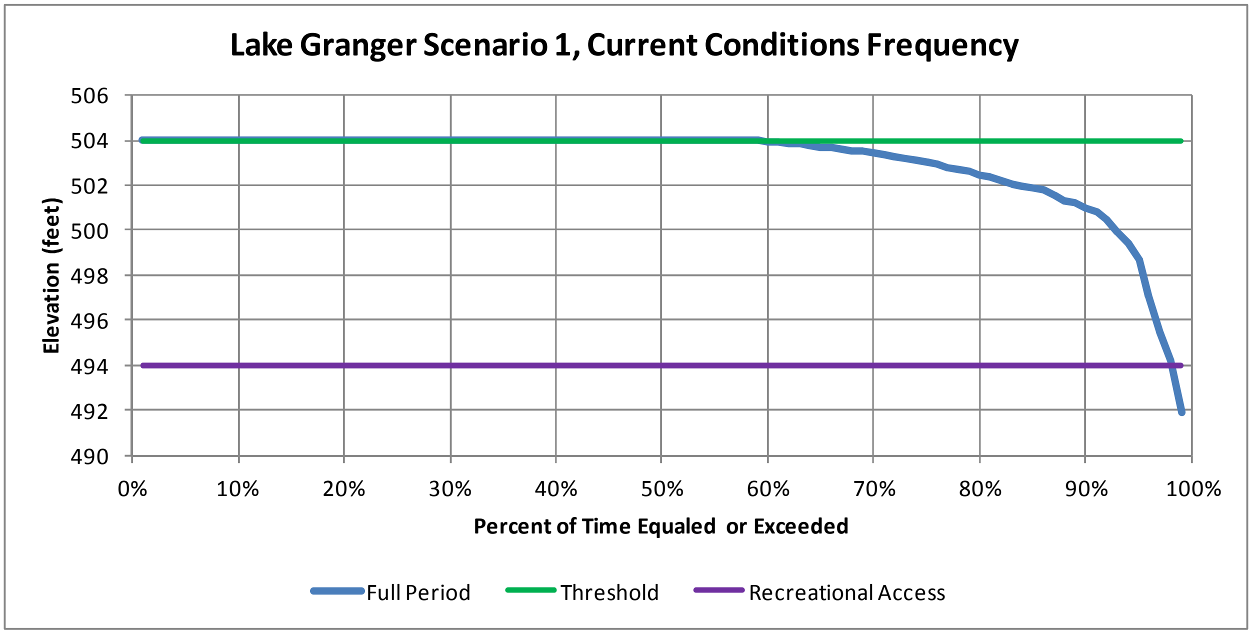

Lake Granbury Scenario 1 Conditions Applied to TCEQ Brazos WAM Period of Record
694
693
692
691
690
689
688
687
686
685
Elevation (feet)
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Elevation (ft)
Threshold
Recreational Access

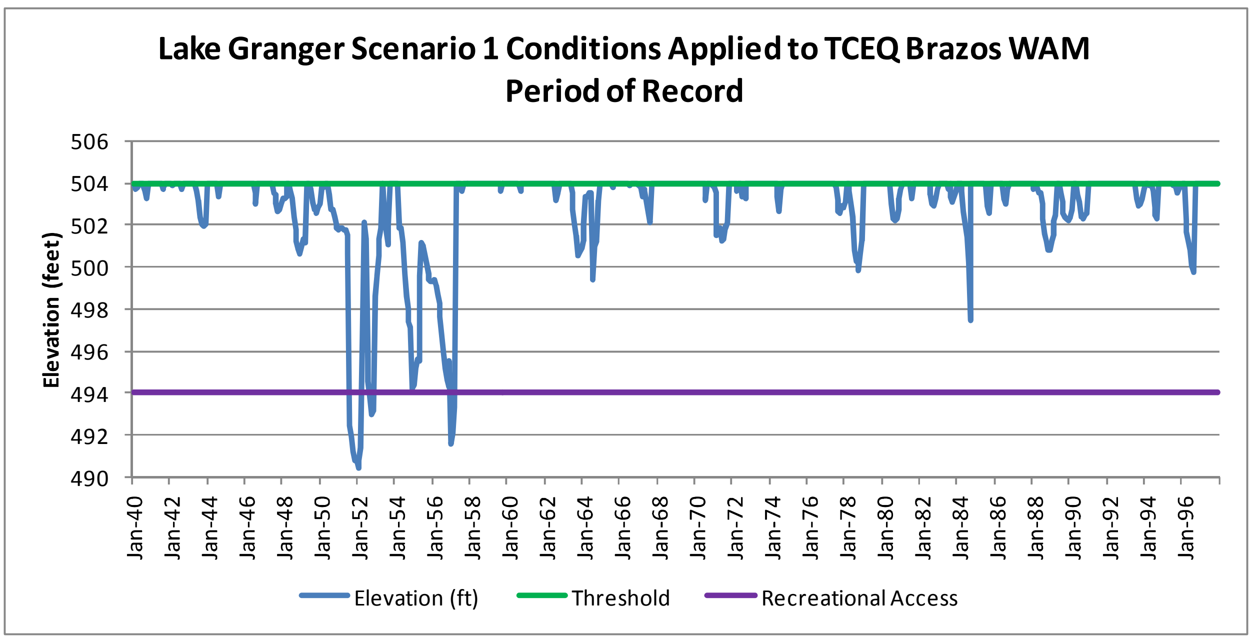

Lake Granbury Scenario 2, All Return Flows - Reservoir Elevations
694
693
692
691
690
689
688
687
686
685
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access Impeded

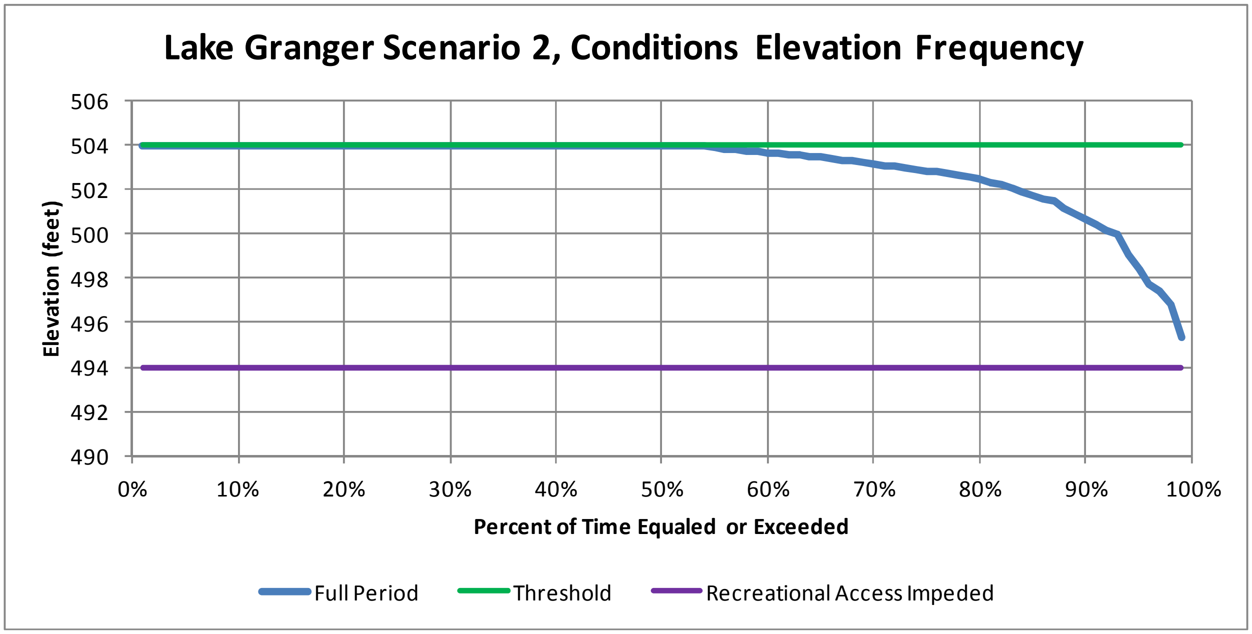

Lake Granbury Scenario 2 Conditions Applied to TCEQ Brazos WAM Period of Record
694
693
692
691
690
689
688
687
686
685
Elevation (feet)
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Elevation (ft)
Threshold
Recreational Access Impeded


Lake Granbury Scenario 3, 2025 Conditions Elevation Frequency
694
693
692
691
690
689
688
687
686
685
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access Impeded

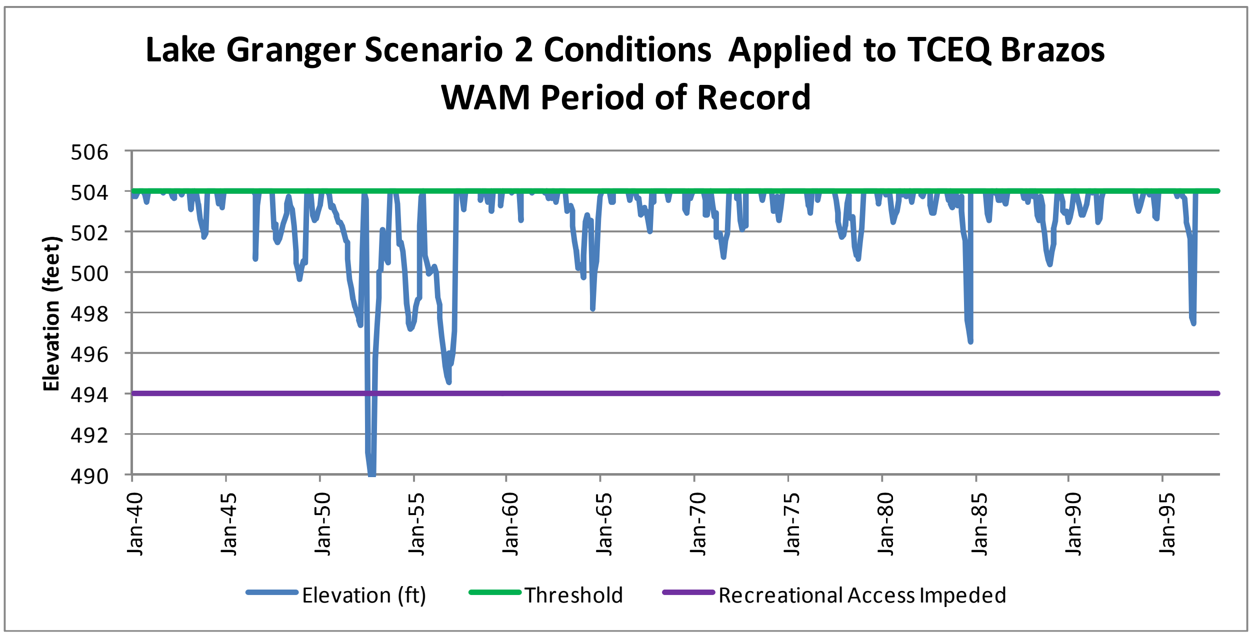

Lake Granbury Scenario 3 Conditons Applied to TCEQ Brazos WAM Period of Record
694
693
692
691
690
689
688
687
686
685
Elevation (feet)
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Elevation (ft)
Threshold
Recreational Access Impeded


Lake Granger Scenario 1, Current Conditions Frequency
Elevation (feet)
506
504
502
500
498
496
494
492
490
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access

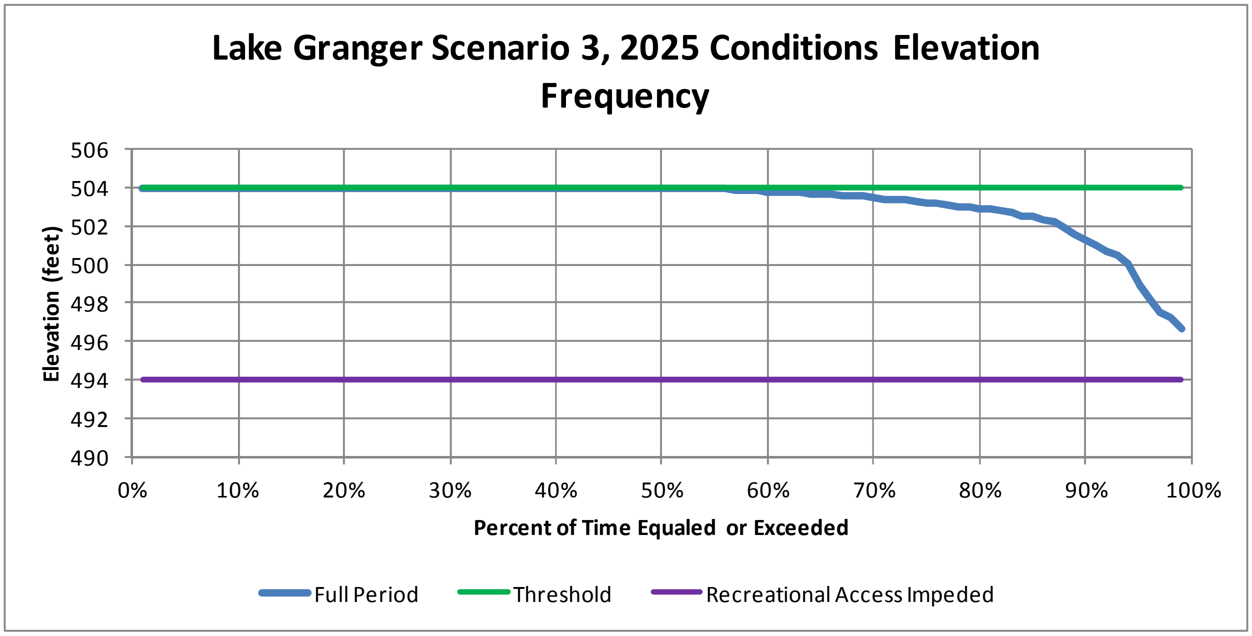

Lake Granger Scenario 1 Conditions Applied to TCEQ Brazos WAM Period of Record
Elevation (feet)
506
504
502
500
498
496
494
492
490
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Elevation (ft)
Threshold
Recreational Access

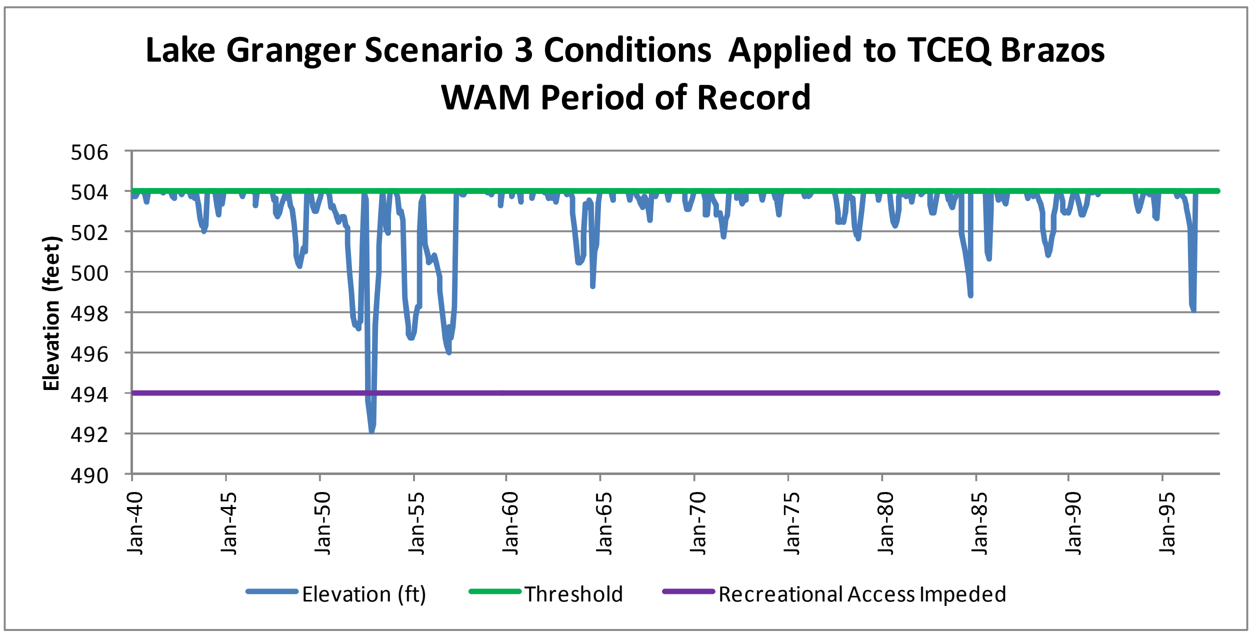


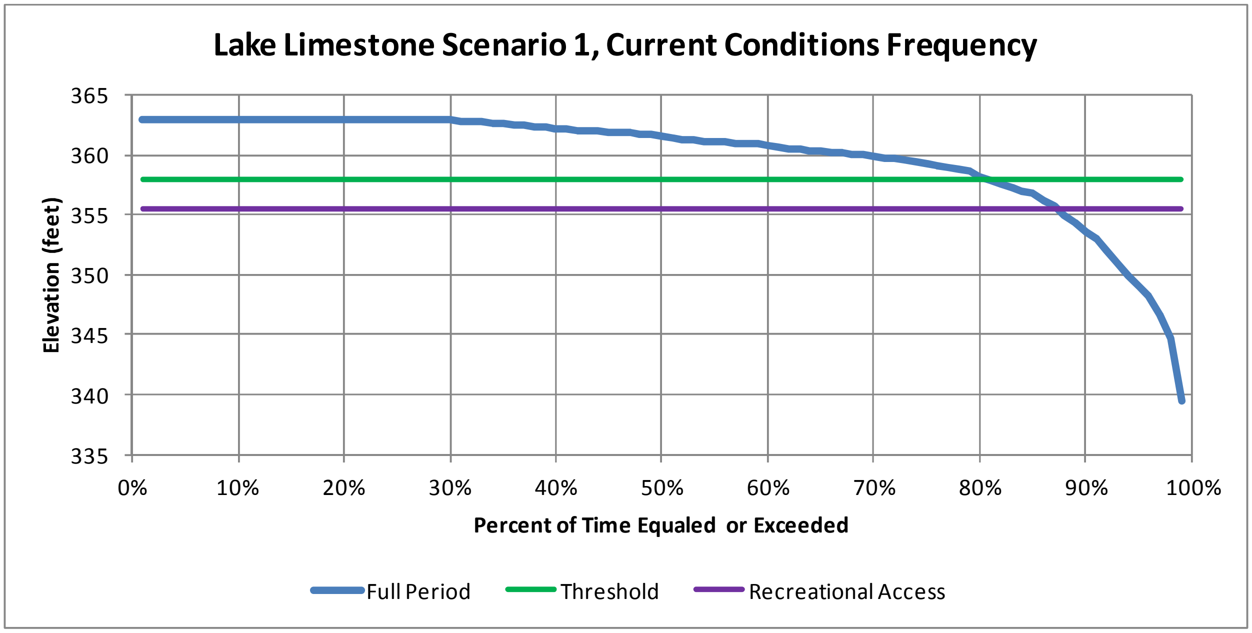
Lake Granger Scenario 2, Conditions Elevation Frequency
506
504
502
500
498
496
494
492
490
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access Impeded

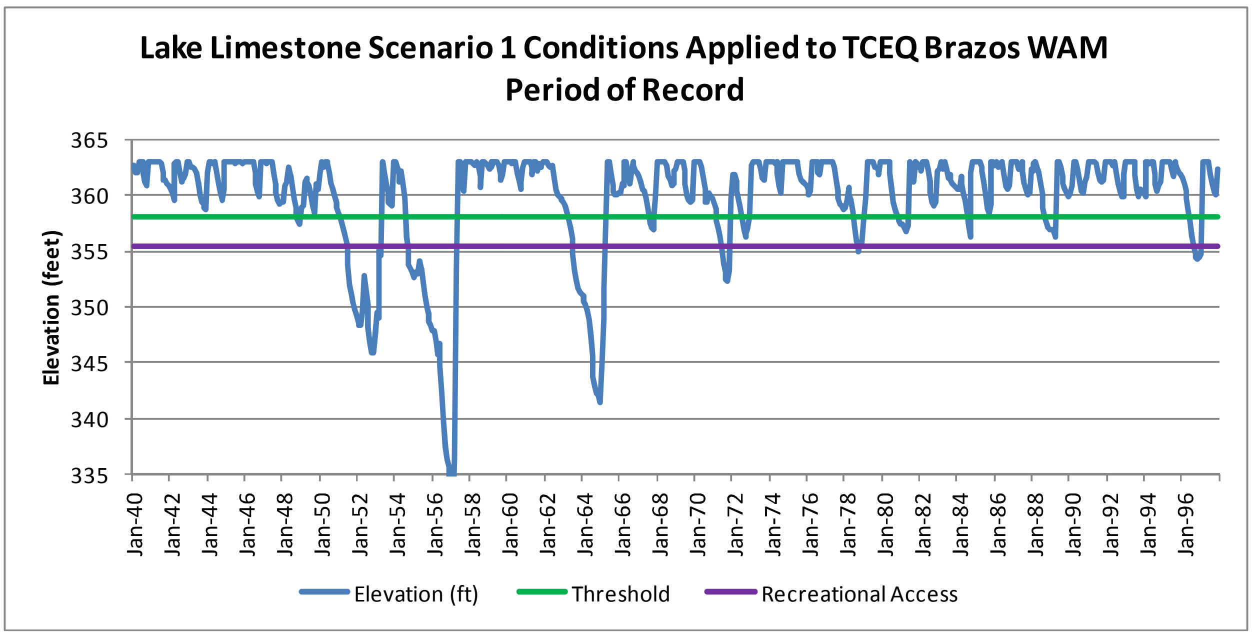
Lake Granger Scenario 2 Conditions Applied to TCEQ Brazos WAM Period of Record
506
504
502
500
498
496
494
492
490
Elevation (feet)
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Elevation (ft)
Threshold
Recreational Access Impeded


Lake Granger Scenario 3, 2025 Conditions Elevation Frequency
506
504
502
500
498
496
494
492
490
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access Impeded

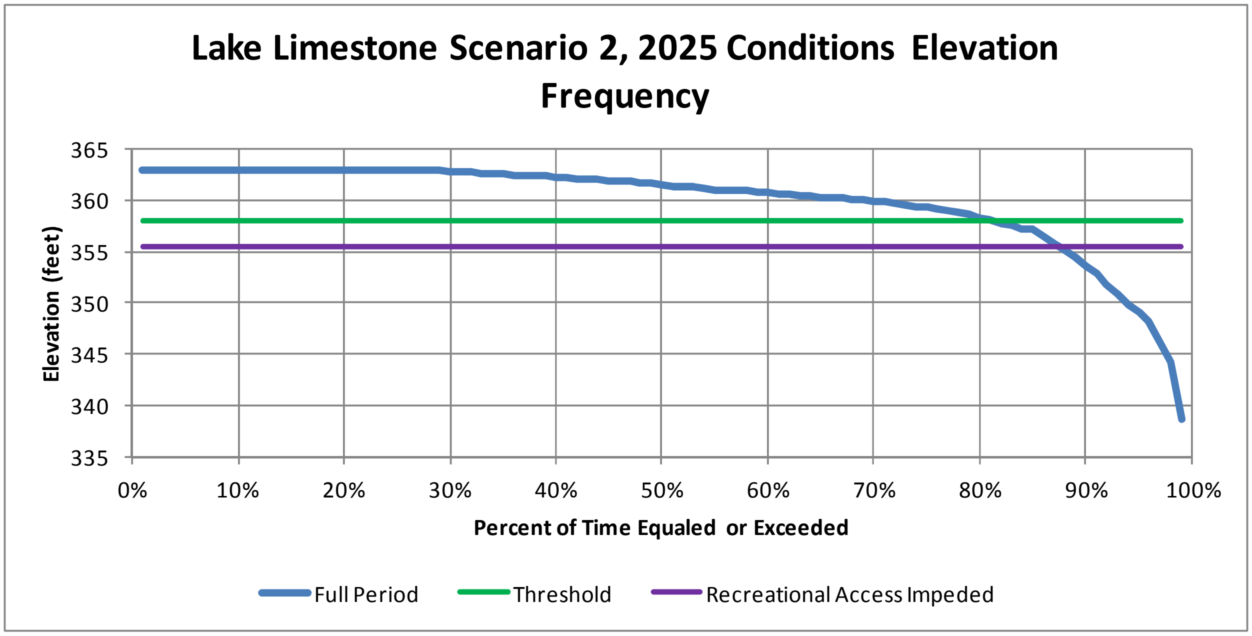

Lake Granger Scenario 3 Conditions Applied to TCEQ Brazos WAM Period of Record
506
504
502
500
498
496
494
492
490
Elevation (feet)
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Elevation (ft)
Threshold
Recreational Access Impeded

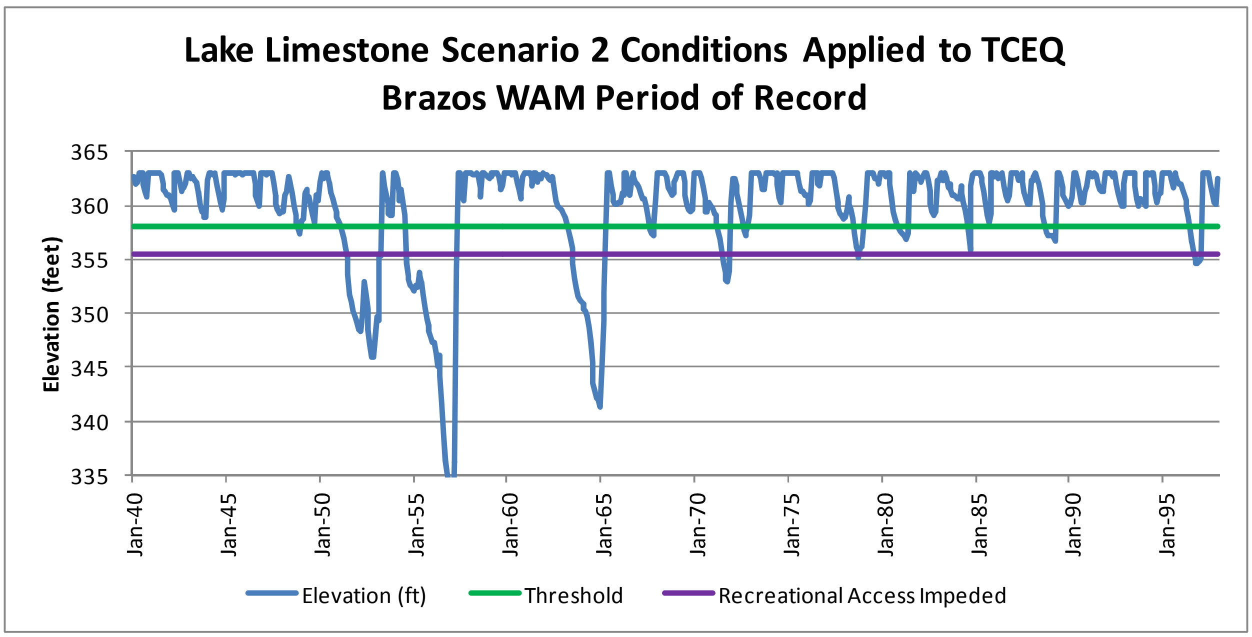


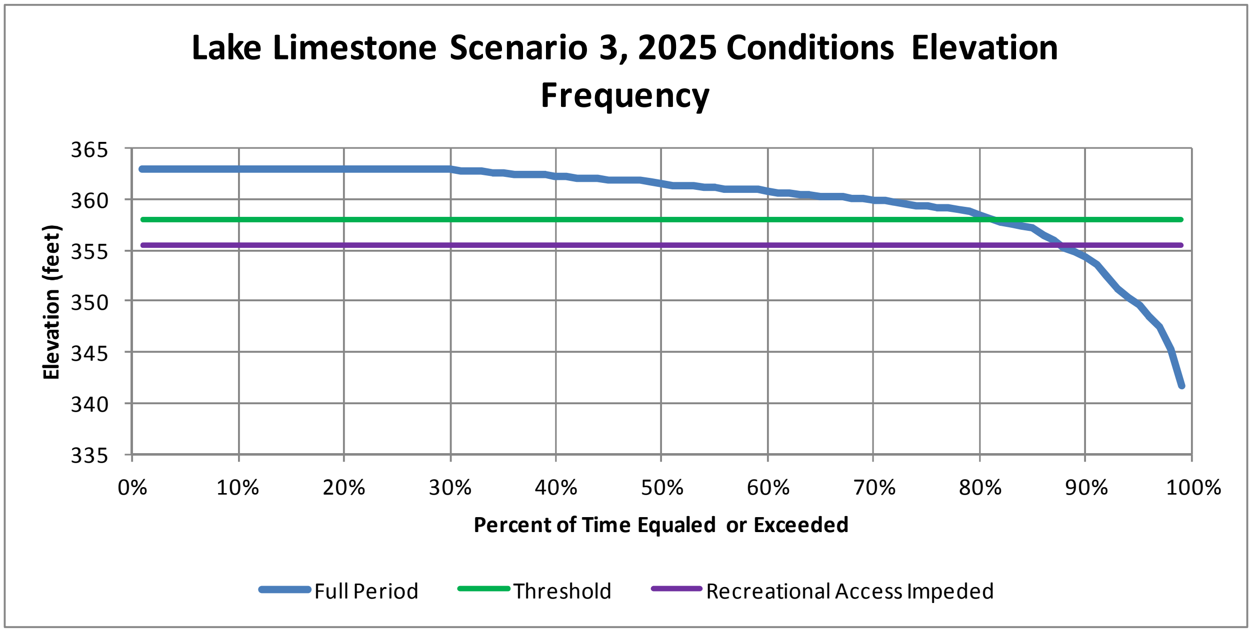
Lake Limestone Scenario 1, Current Conditions Frequency
365
360
355
350
345
340
335
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access

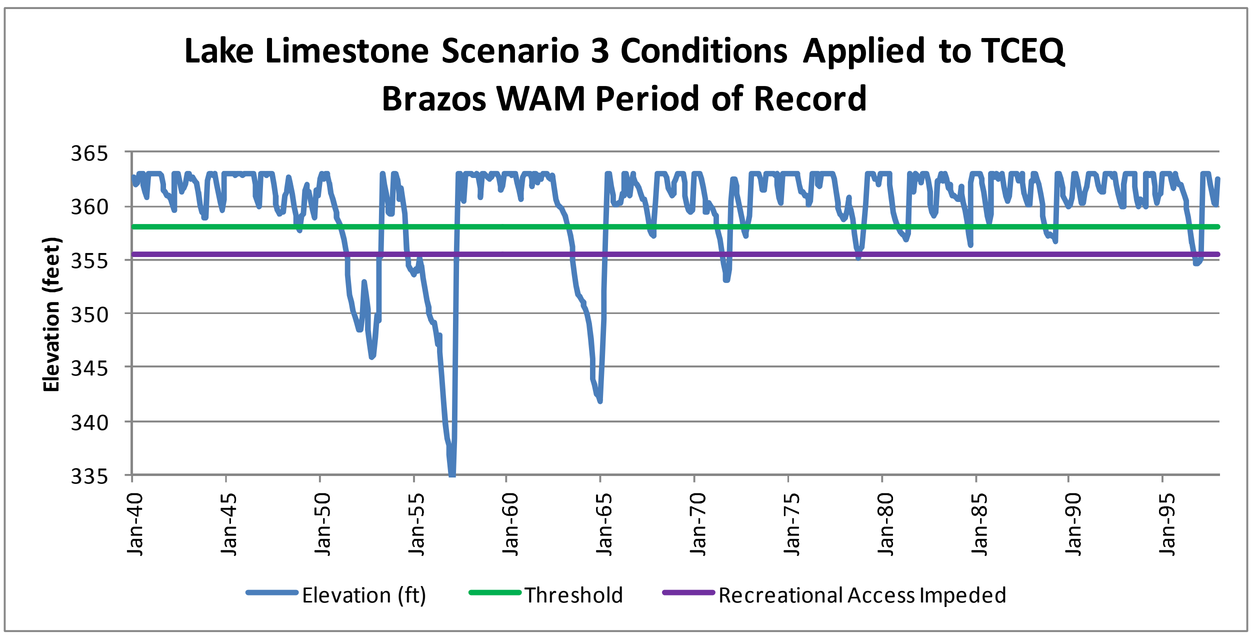



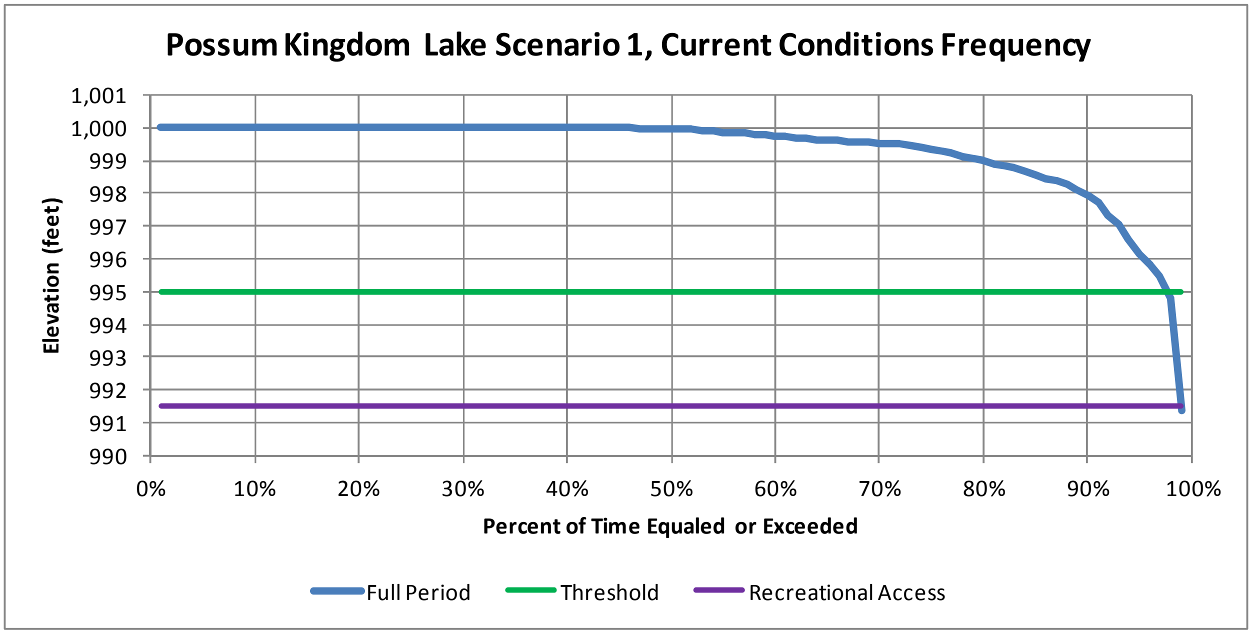
Lake Limestone Scenario 1 Conditions Applied to TCEQ Brazos WAM Period of Record
365
360
355
350
345
340
335
Elevation (feet)
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Elevation (ft)
Threshold
Recreational Access

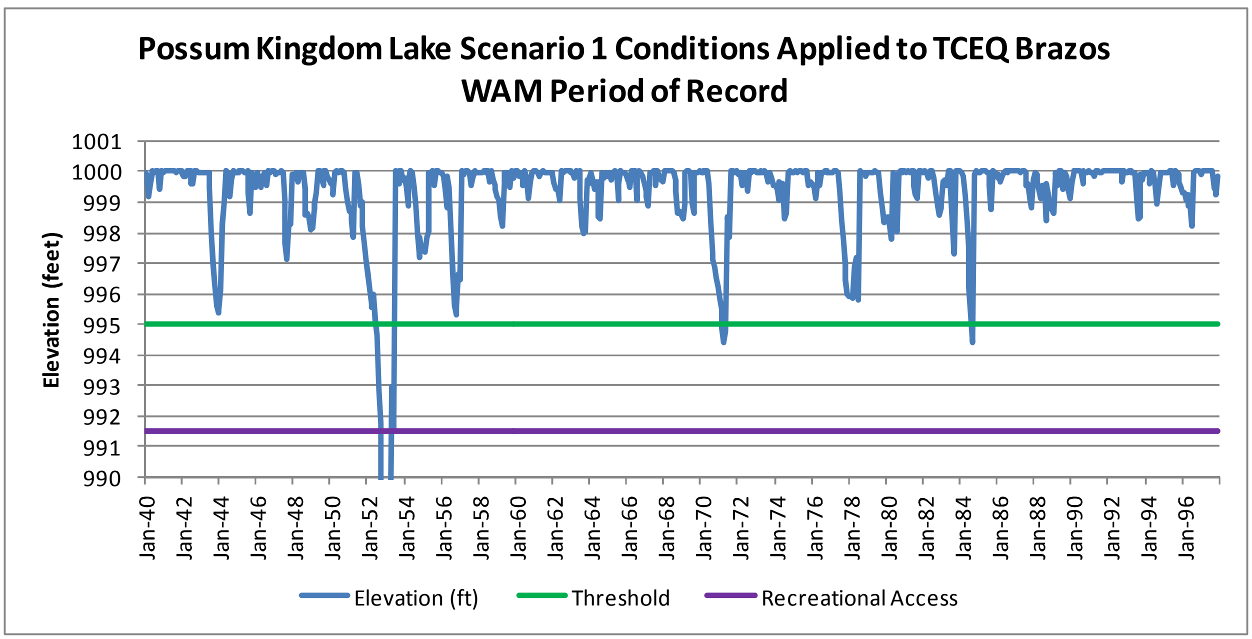

Lake Limestone Scenario 2, 2025 Conditions Elevation Frequency
365
360
355
350
345
340
335
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access Impeded

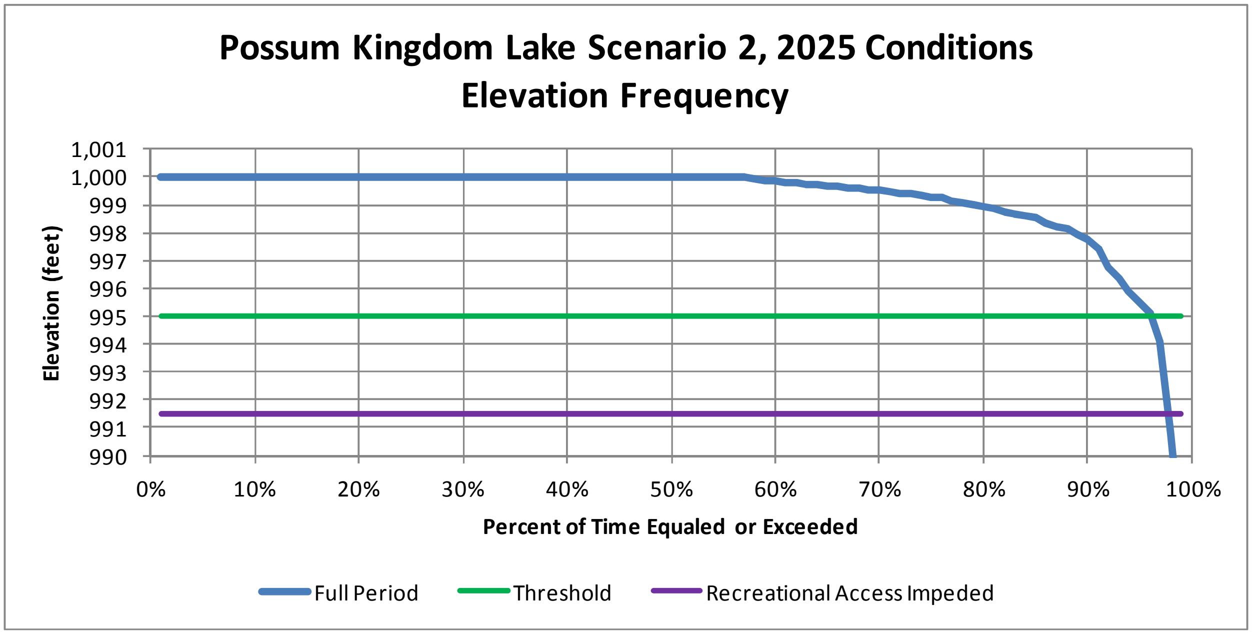

Lake Limestone Scenario 2 Conditions Applied to TCEQ Brazos WAM Period of Record
365
360
355
350
345
340
335
Elevation (feet)
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Elevation (ft)
Threshold
Recreational Access Impeded


Lake Limestone Scenario 3, 2025 Conditions Elevation Frequency
365
360
355
350
345
340
335
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Elevation (feet)
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access Impeded

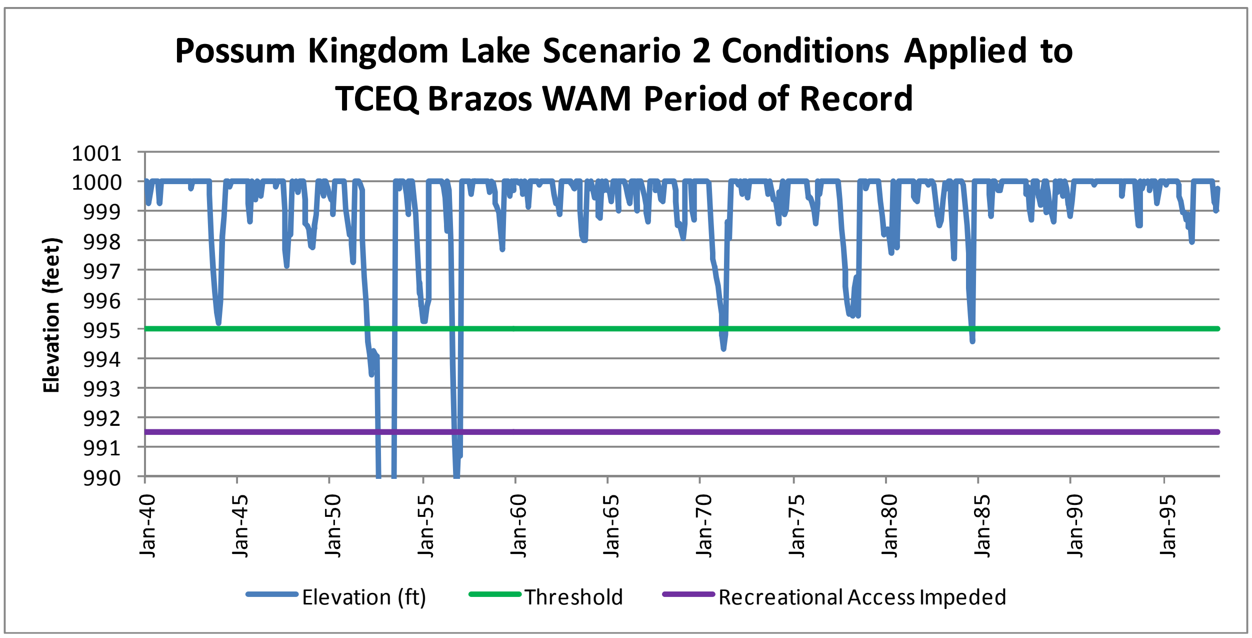

Lake Limestone Scenario 3 Conditions Applied to TCEQ Brazos WAM Period of Record
365
360
355
350
345
340
335
Elevation (feet)
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Elevation (ft)
Threshold
Recreational Access Impeded


Possum Kingdom Lake Scenario 1, Current Conditions Frequency
1,001
1,000
999
998
997
996
995
994
993
992
991
990
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access

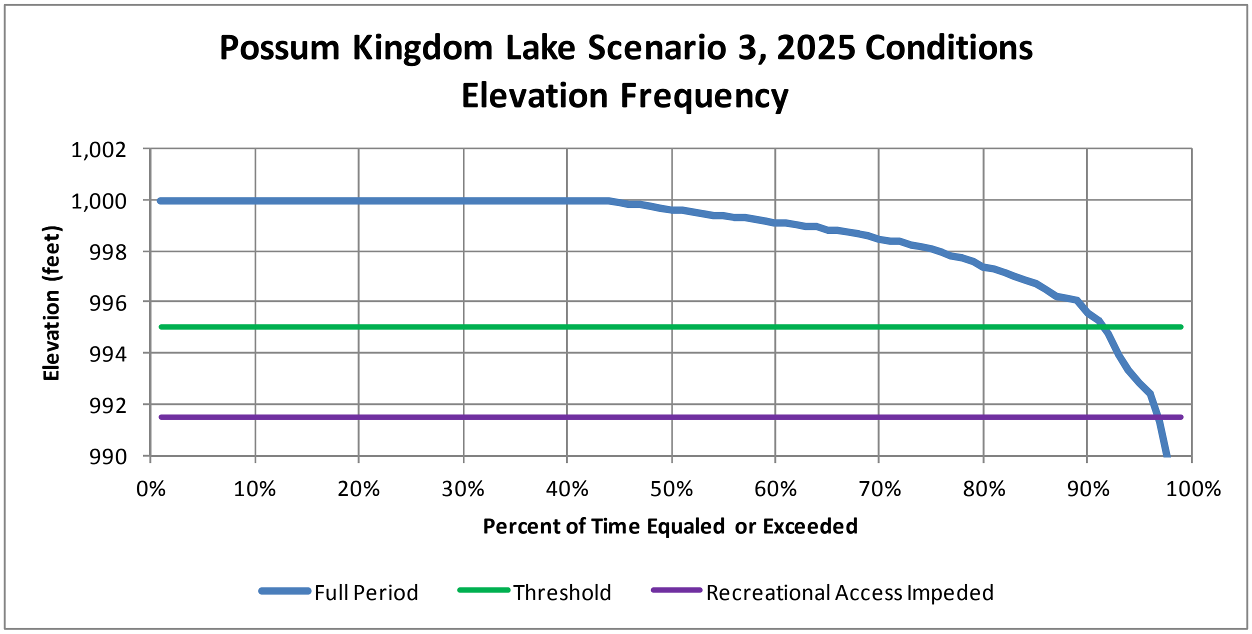

Possum Kingdom Lake Scenario 1 Conditions Applied to TCEQ Brazos WAM Period of Record
1001
1000
999
998
997
996
995
994
993
992
991
990
Elevation (feet)
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Elevation (ft)
Threshold
Recreational Access

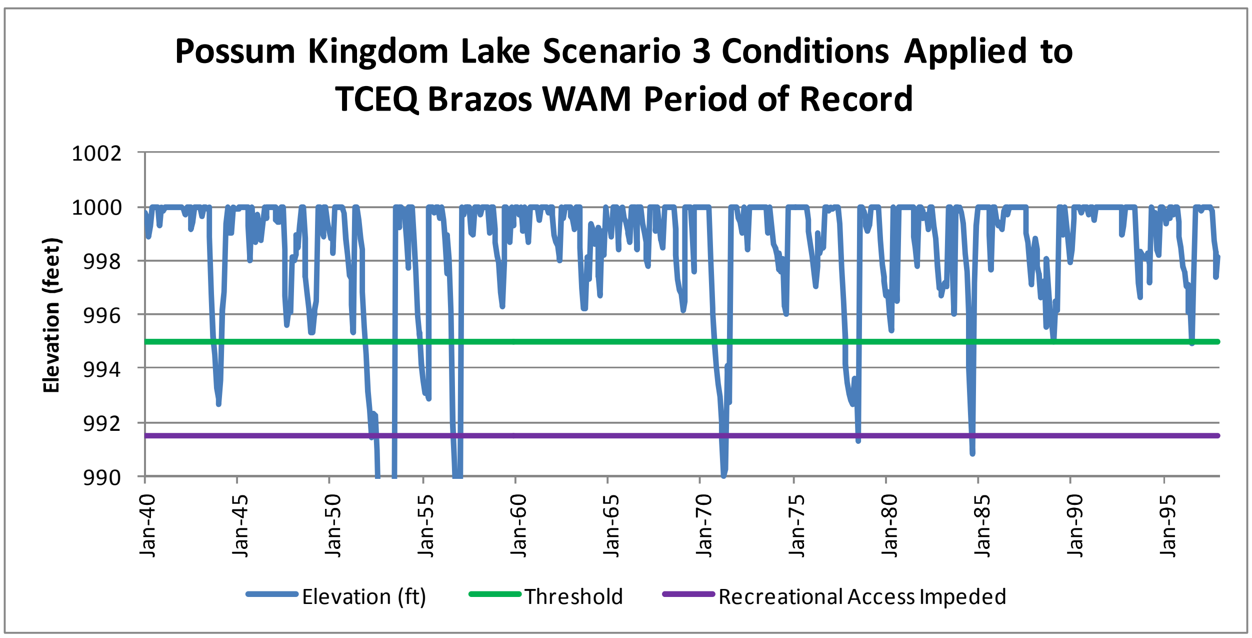


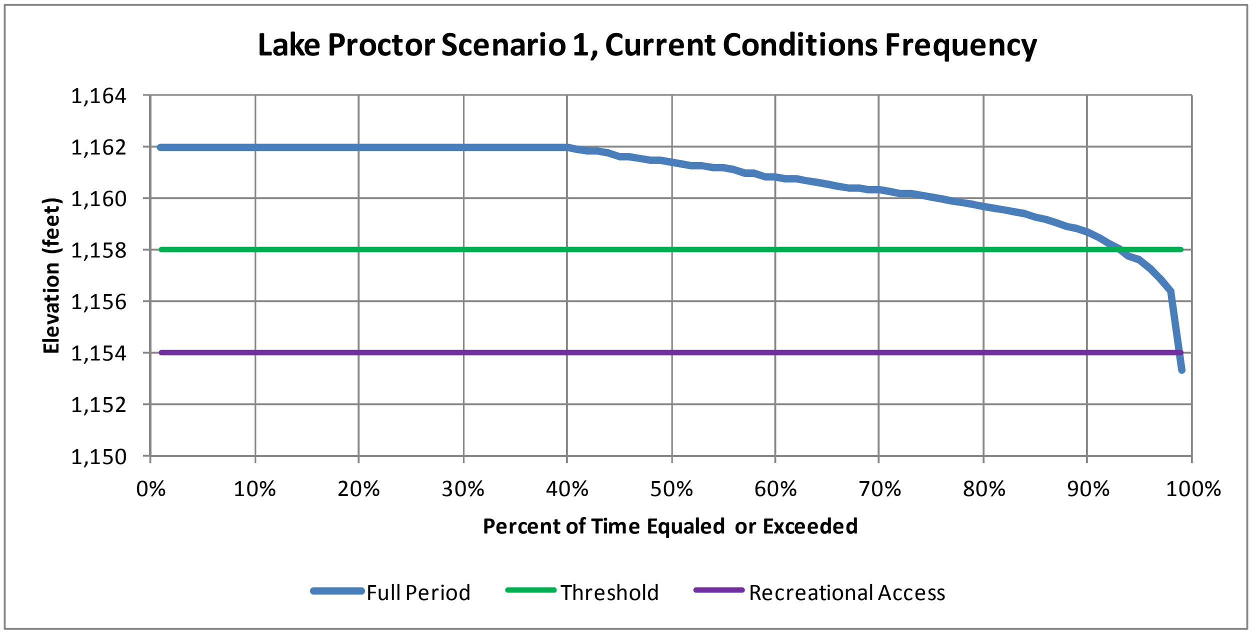
Possum Kingdom Lake Scenario 2, 2025 Conditions
Elevation Frequency
Elevation (feet)
1,001
1,000
999
998
997
996
995
994
993
992
991
990
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access Impeded

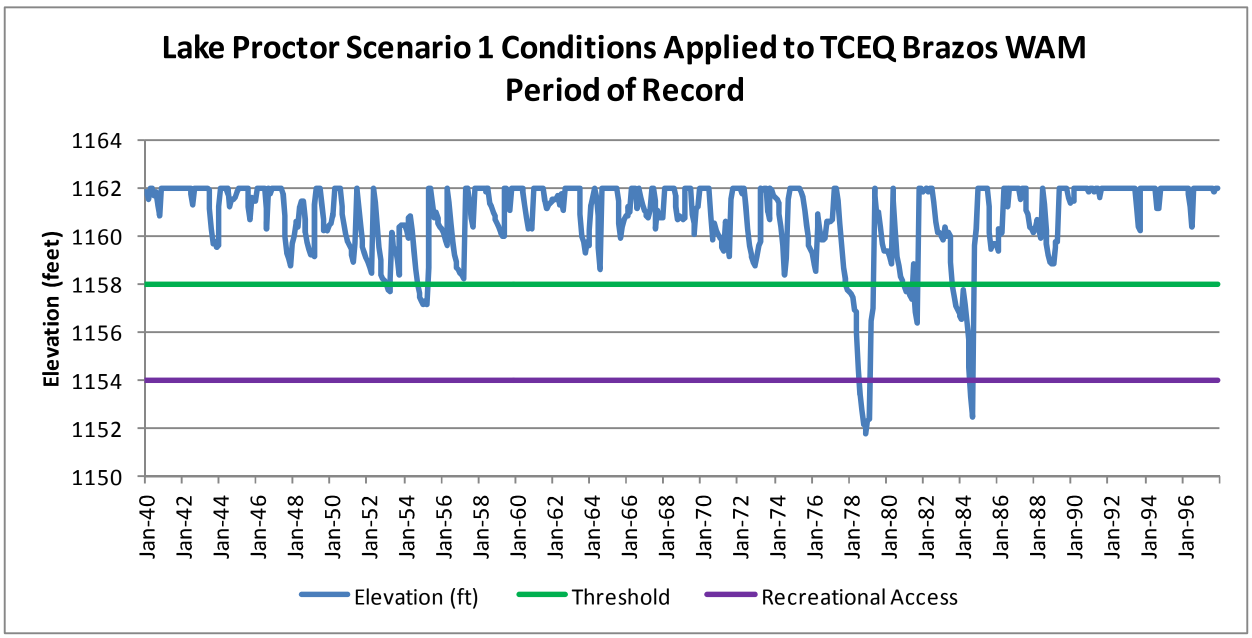



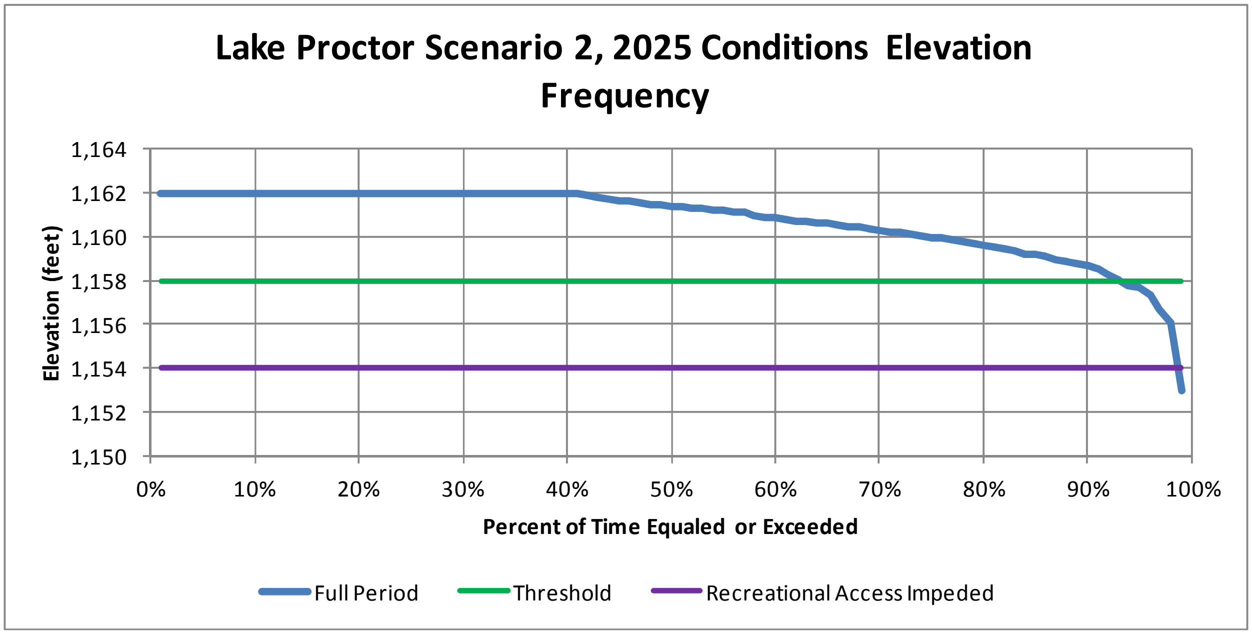
Possum Kingdom Lake Scenario 2 Conditions Applied to
TCEQ Brazos WAM Period of Record
Elevation (feet)
1001
1000
999
998
997
996
995
994
993
992
991
990
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Elevation (ft)
Threshold
Recreational Access Impeded


Possum Kingdom Lake Scenario 3, 2025 Conditions
Elevation Frequency
1,002
1,000
998
996
994
992
990
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access Impeded

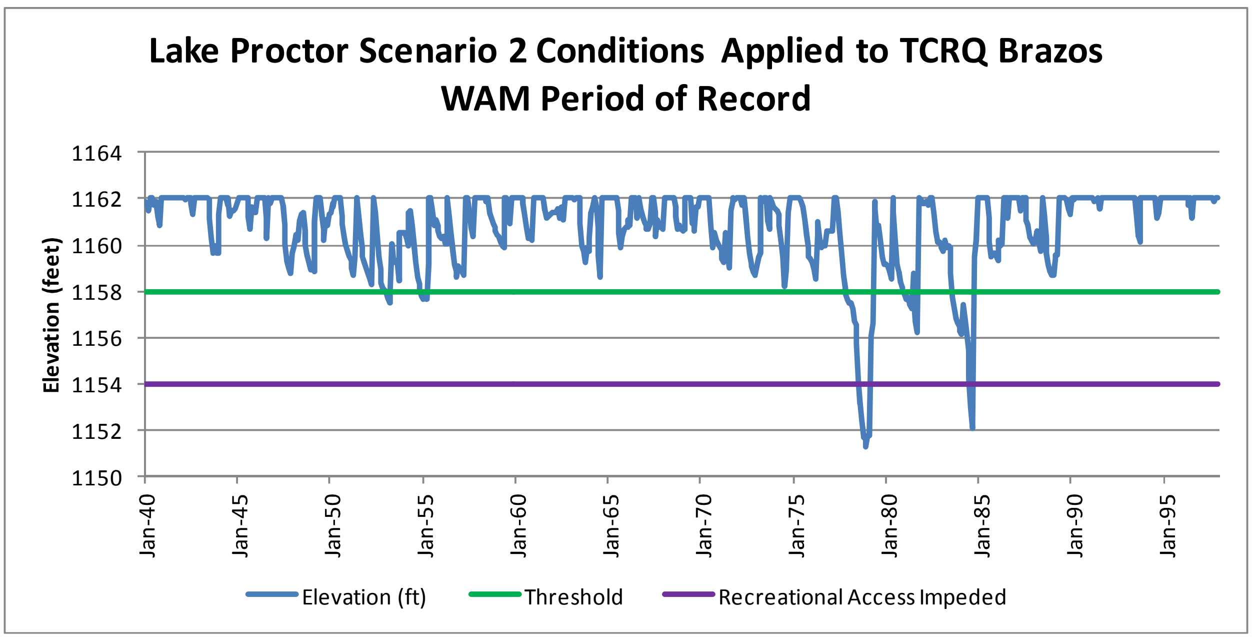

Possum Kingdom Lake Scenario 3 Conditions Applied to
TCEQ Brazos WAM Period of Record
1002
1000
998
996
994
992
990
Elevation (feet)
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Elevation (ft)
Threshold
Recreational Access Impeded


Lake Proctor Scenario 1, Current Conditions Frequency
1,164
1,162
1,160
1,158
1,156
1,154
1,152
1,150
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access

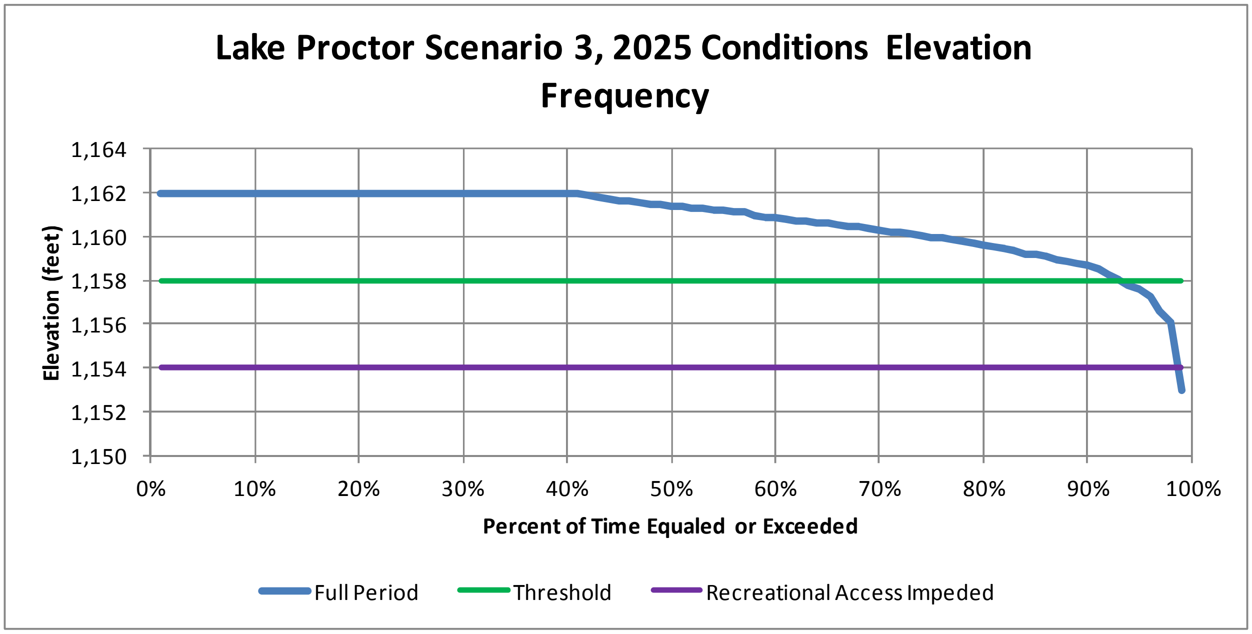

Lake Proctor Scenario 1 Conditions Applied to TCEQ Brazos WAM Period of Record
1164
1162
1160
1158
1156
1154
1152
1150
Elevation (feet)
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Elevation (ft)
Threshold
Recreational Access

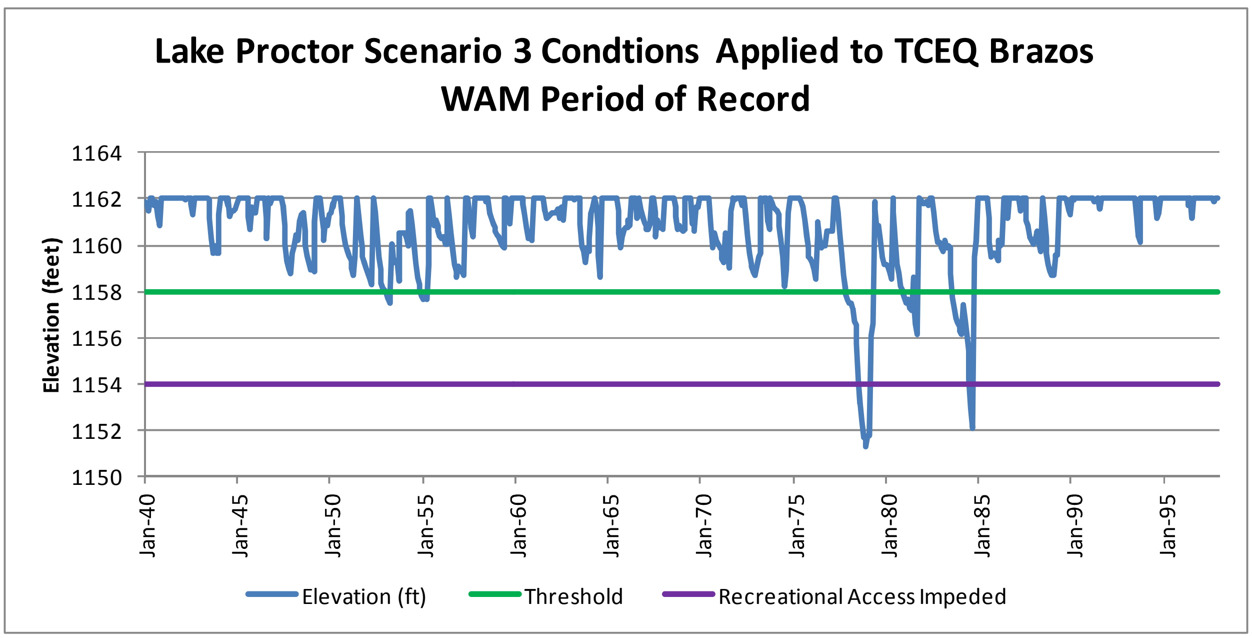


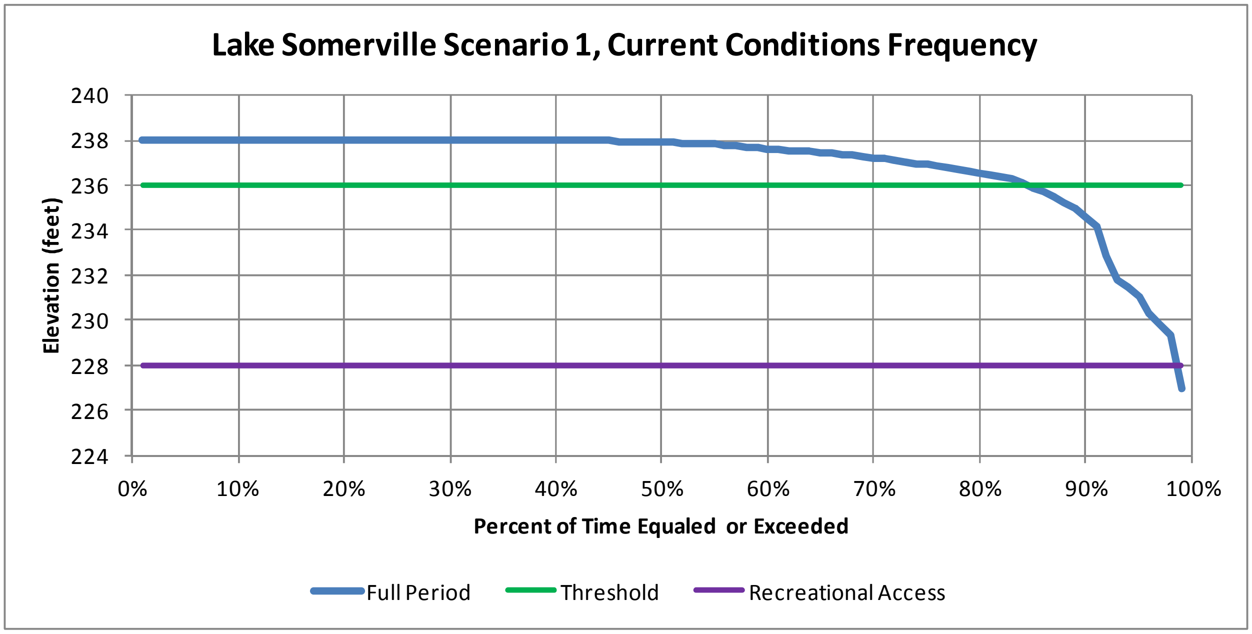
Lake Proctor Scenario 2, 2025 Conditions Elevation Frequency
Elevation (feet)
1,164
1,162
1,160
1,158
1,156
1,154
1,152
1,150
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access Impeded

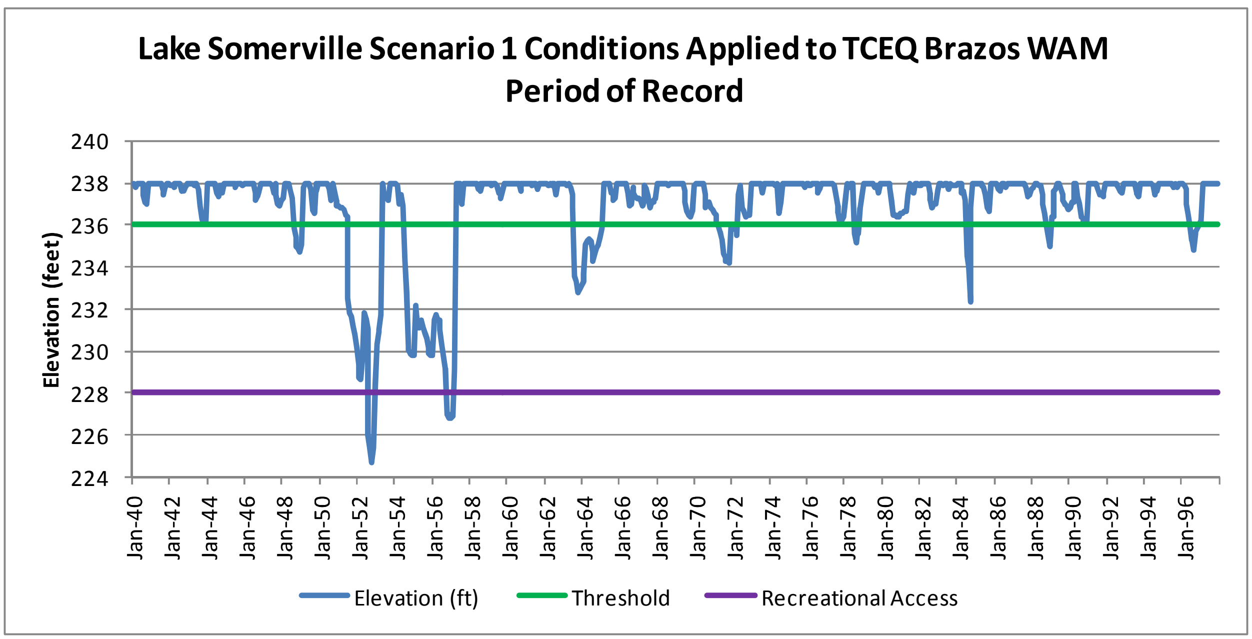



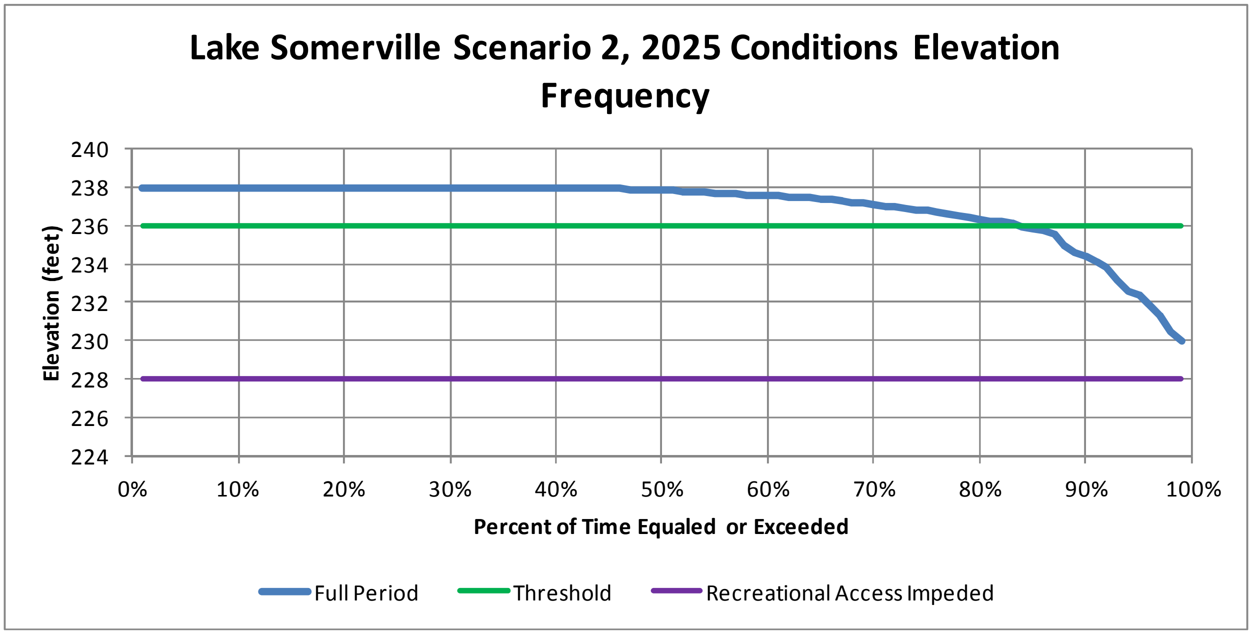
Lake Proctor Scenario 2 Conditions Applied to TCRQ Brazos WAM Period of Record
Elevation (feet)
1164
1162
1160
1158
1156
1154
1152
1150
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Elevation (ft)
Threshold
Recreational Access Impeded

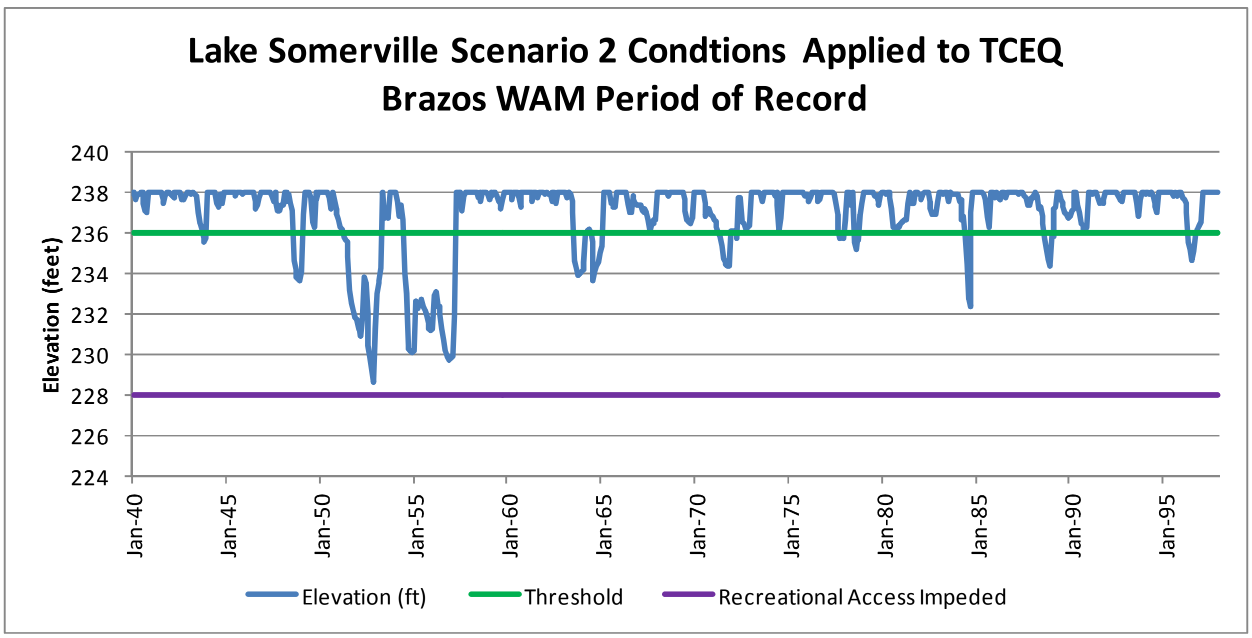

Lake Proctor Scenario 3, 2025 Conditions Elevation Frequency
1,164
1,162
1,160
1,158
1,156
1,154
1,152
1,150
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access Impeded

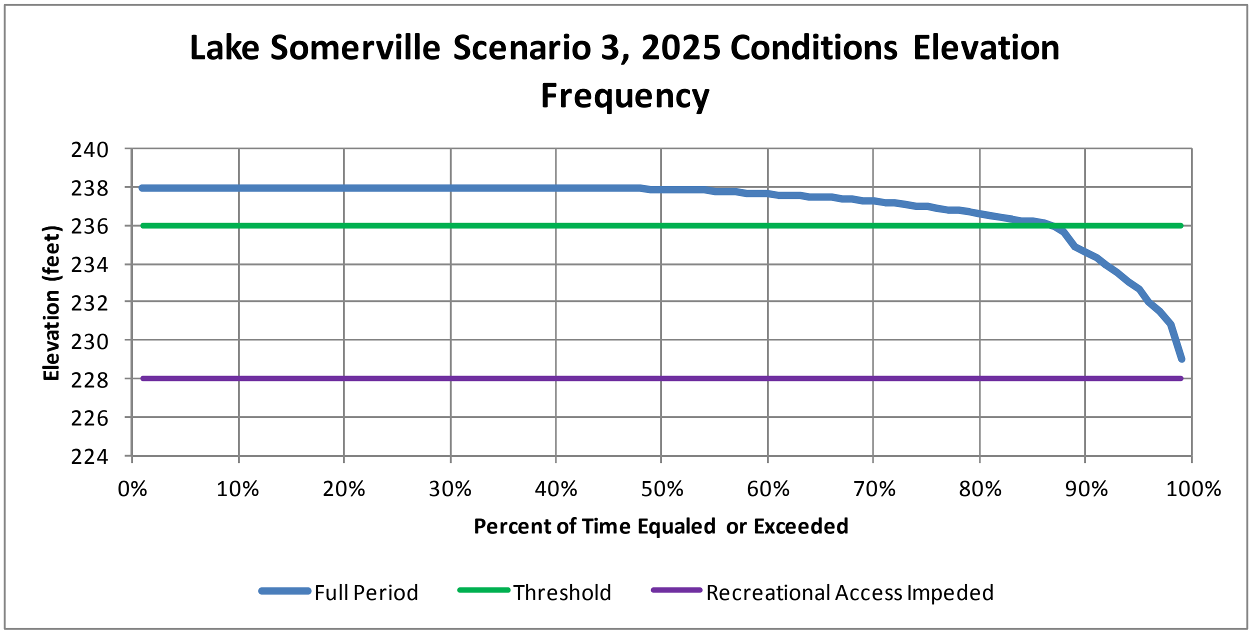

Lake Proctor Scenario 3 Condtions Applied to TCEQ Brazos WAM Period of Record
1164
1162
1160
1158
1156
1154
1152
1150
Elevation (feet)
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Elevation (ft)
Threshold
Recreational Access Impeded

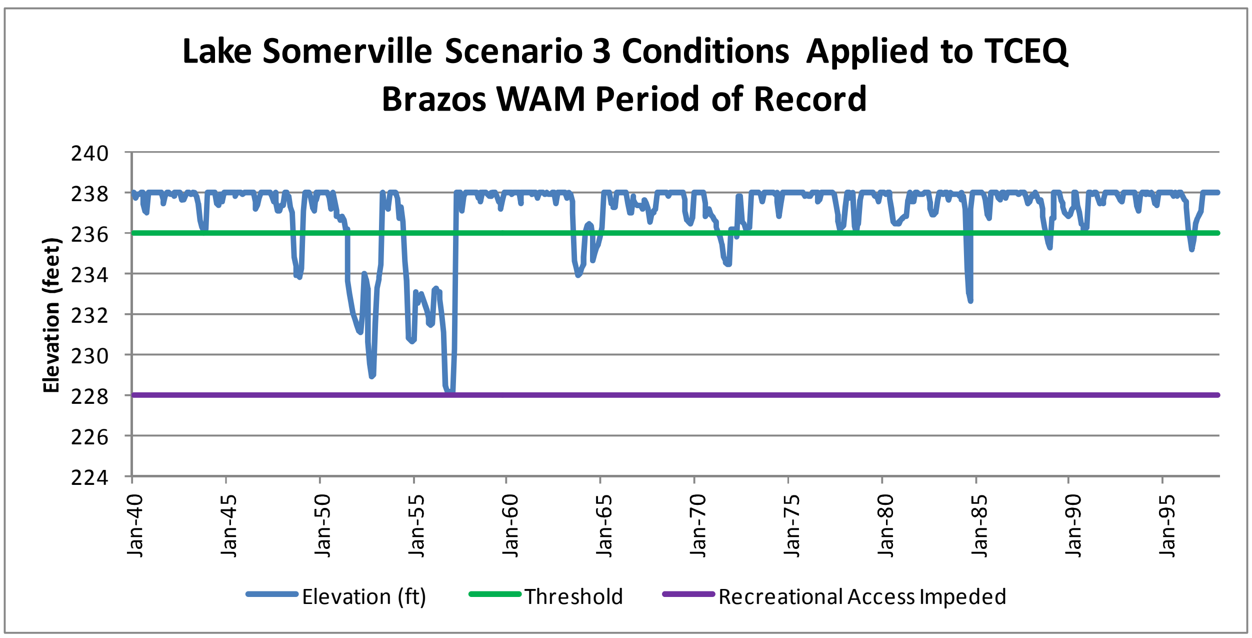

Lake Somerville Scenario 1, Current Conditions Frequency
240
238
236
234
232
230
228
226
224
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access

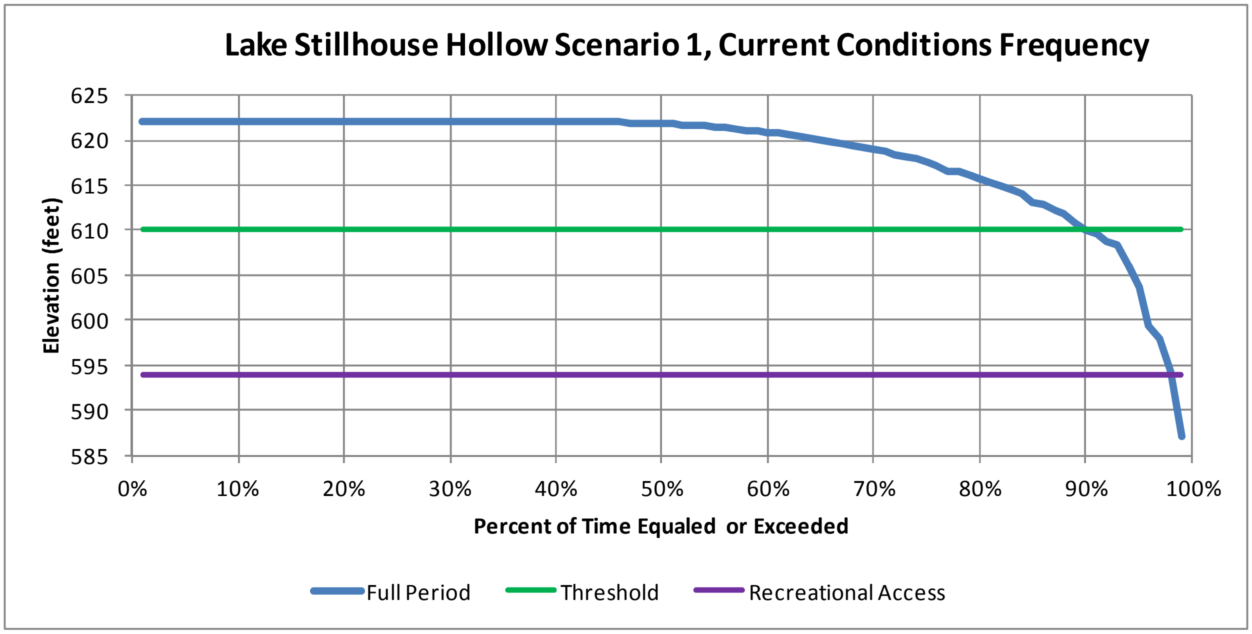

Lake Somerville Scenario 1 Conditions Applied to TCEQ Brazos WAM Period of Record
240
238
236
234
232
230
228
226
224
Elevation (feet)
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Elevation (ft)
Threshold
Recreational Access


Lake Somerville Scenario 2, 2025 Conditions Elevation Frequency
240
238
236
234
232
230
228
226
224
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access Impeded

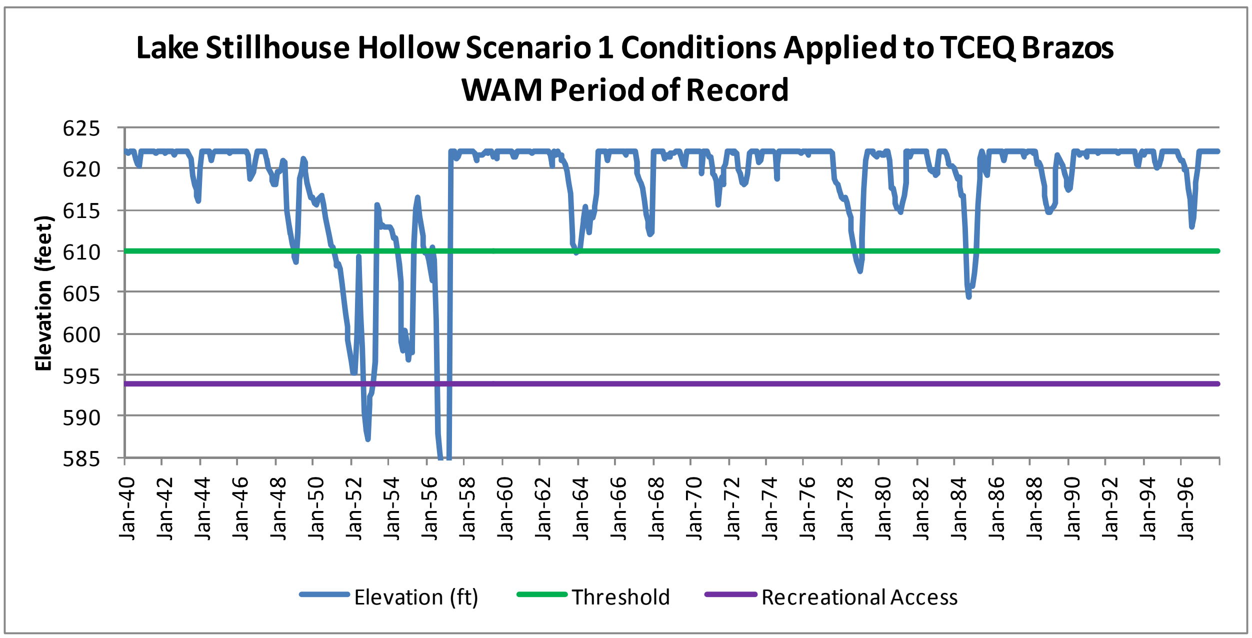

Lake Somerville Scenario 2 Condtions Applied to TCEQ Brazos WAM Period of Record
240
238
236
234
232
230
228
226
224
Elevation (feet)
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Elevation (ft)
Threshold
Recreational Access Impeded


Lake Somerville Scenario 3, 2025 Conditions Elevation Frequency
240
238
236
234
232
230
228
226
224
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access Impeded

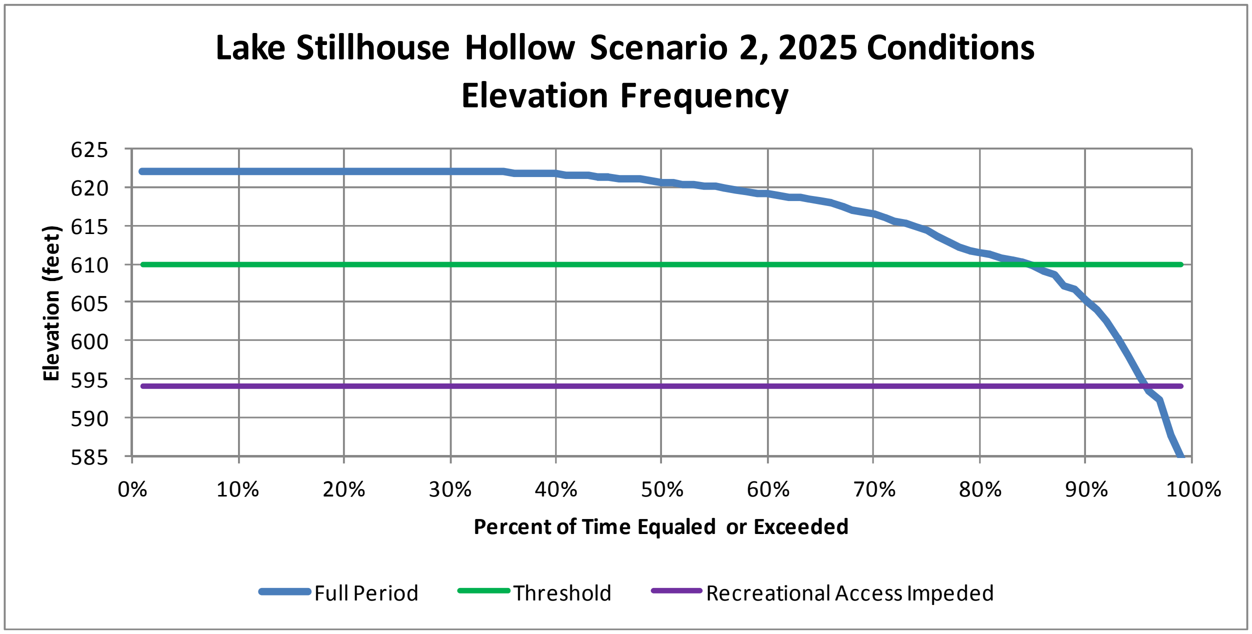

Lake Somerville Scenario 3 Conditions Applied to TCEQ Brazos WAM Period of Record
240
238
236
234
232
230
228
226
224
Elevation (feet)
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Elevation (ft)
Threshold
Recreational Access Impeded

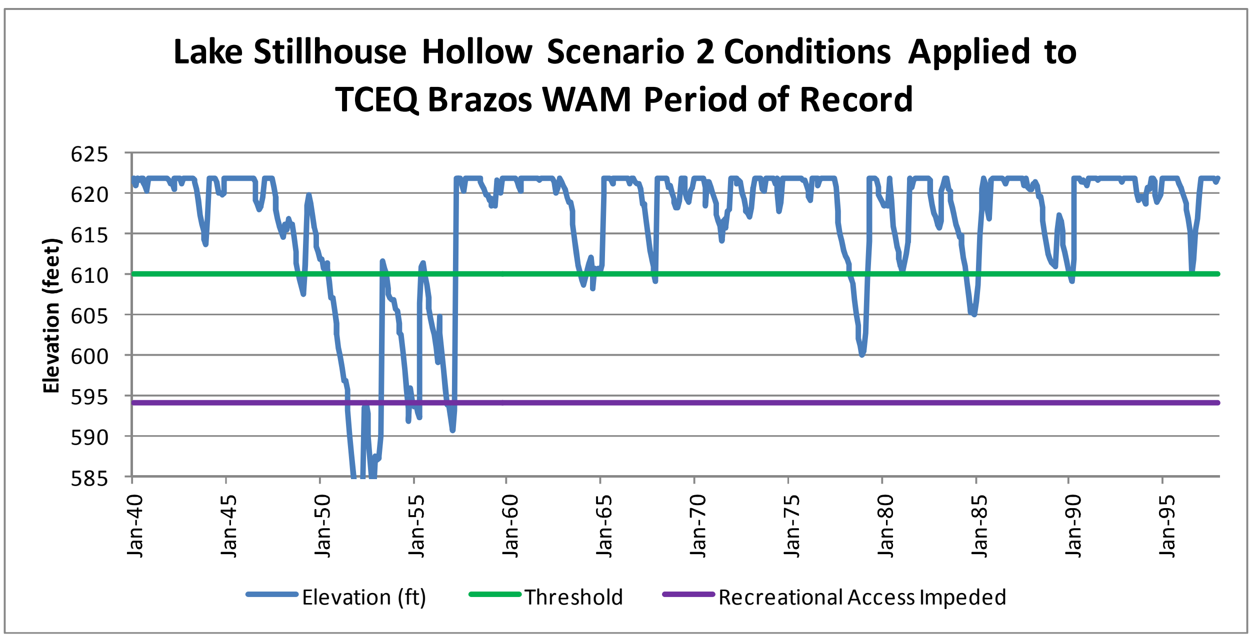


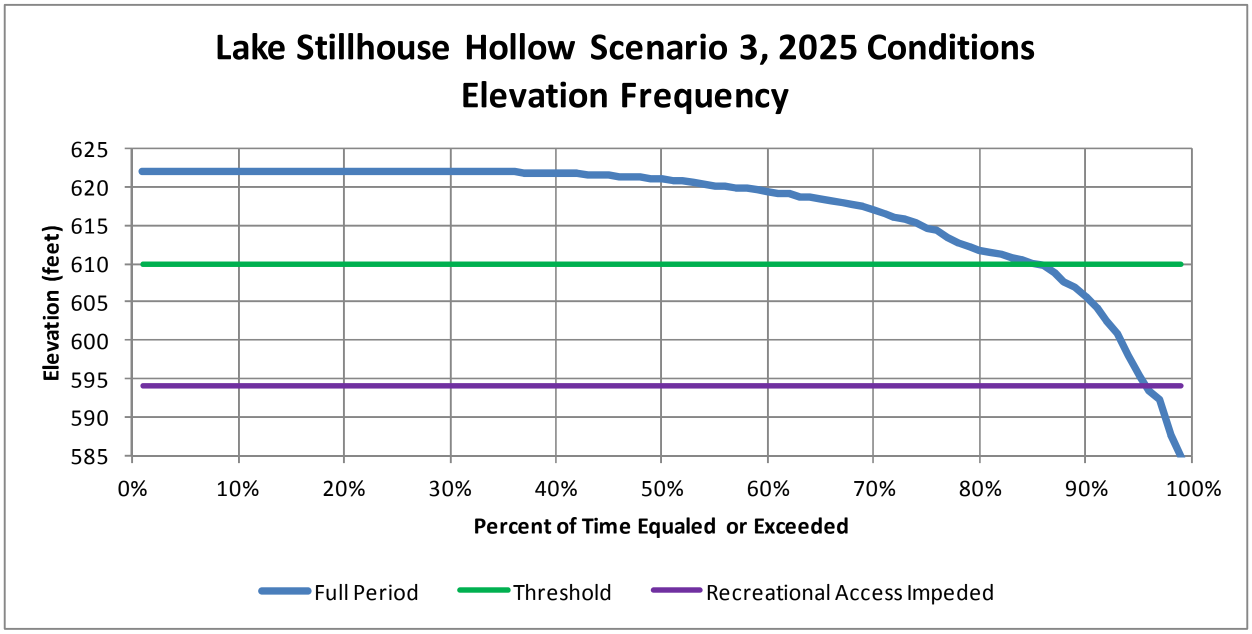
Lake Stillhouse Hollow Scenario 1, Current Conditions Frequency
625
620
615
610
605
600
595
590
585
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access

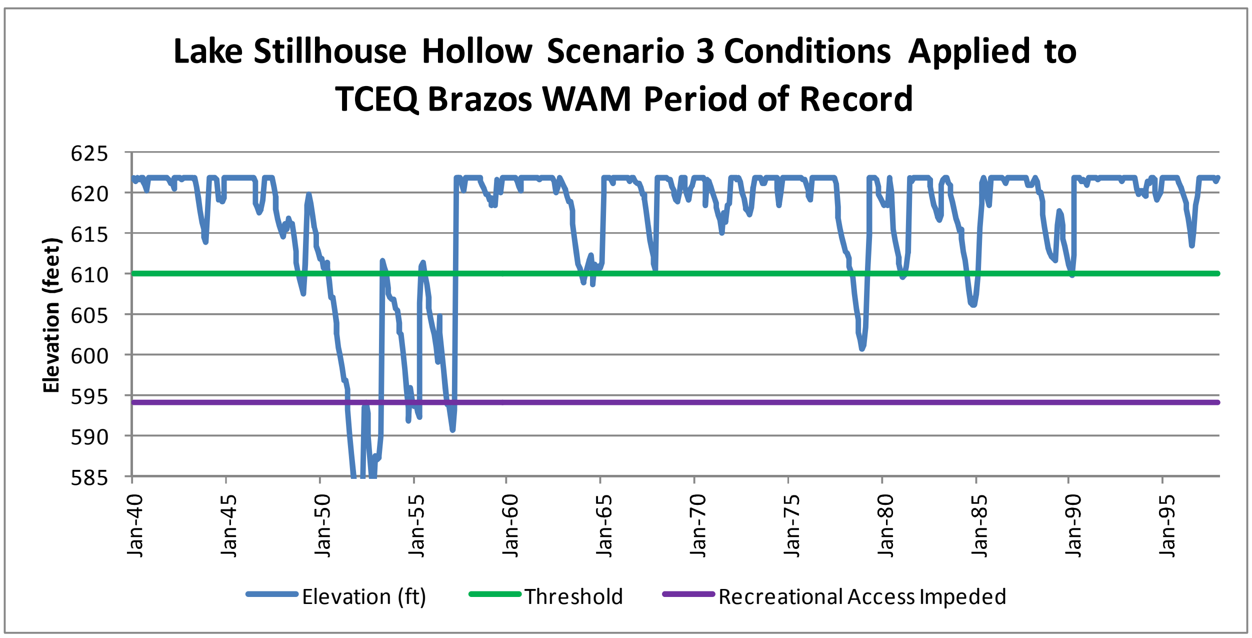



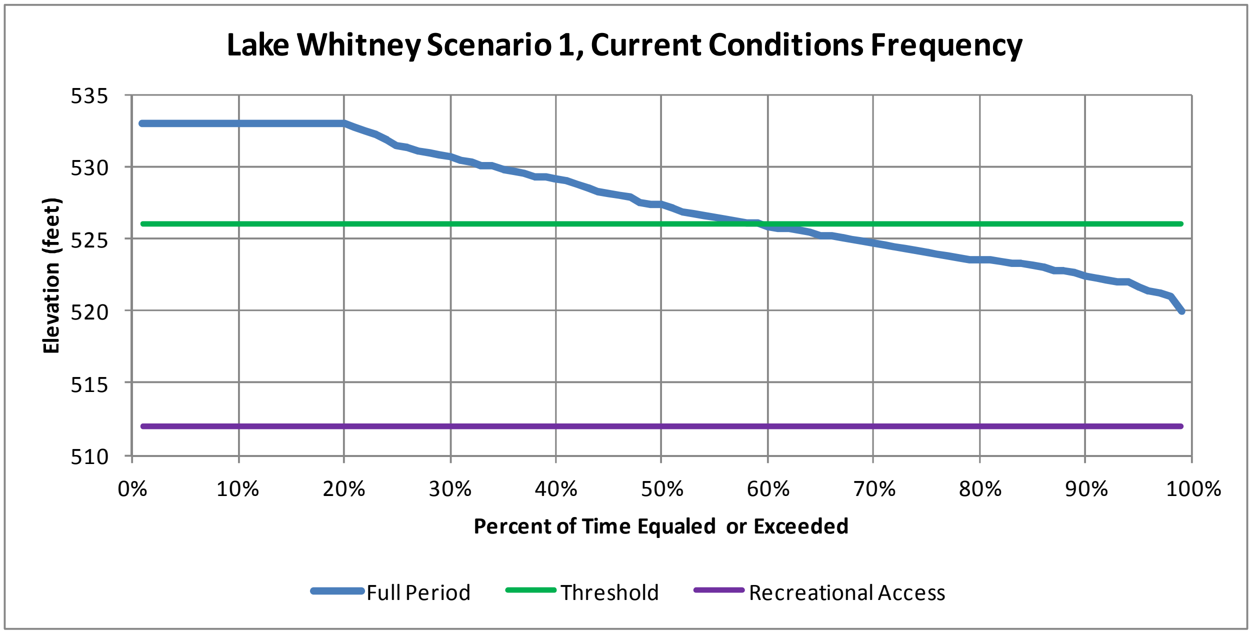
Lake Stillhouse Hollow Scenario 1 Conditions Applied to TCEQ Brazos WAM Period of Record
625
620
615
610
605
600
595
590
585
Elevation (feet)
Jan-40
Jan-42
Jan-44
Jan-46
Jan-48
Jan-50
Jan-52
Jan-54
Jan-56
Jan-58
Jan-60
Jan-62
Jan-64
Jan-66
Jan-68
Jan-70
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Elevation (ft)
Threshold
Recreational Access

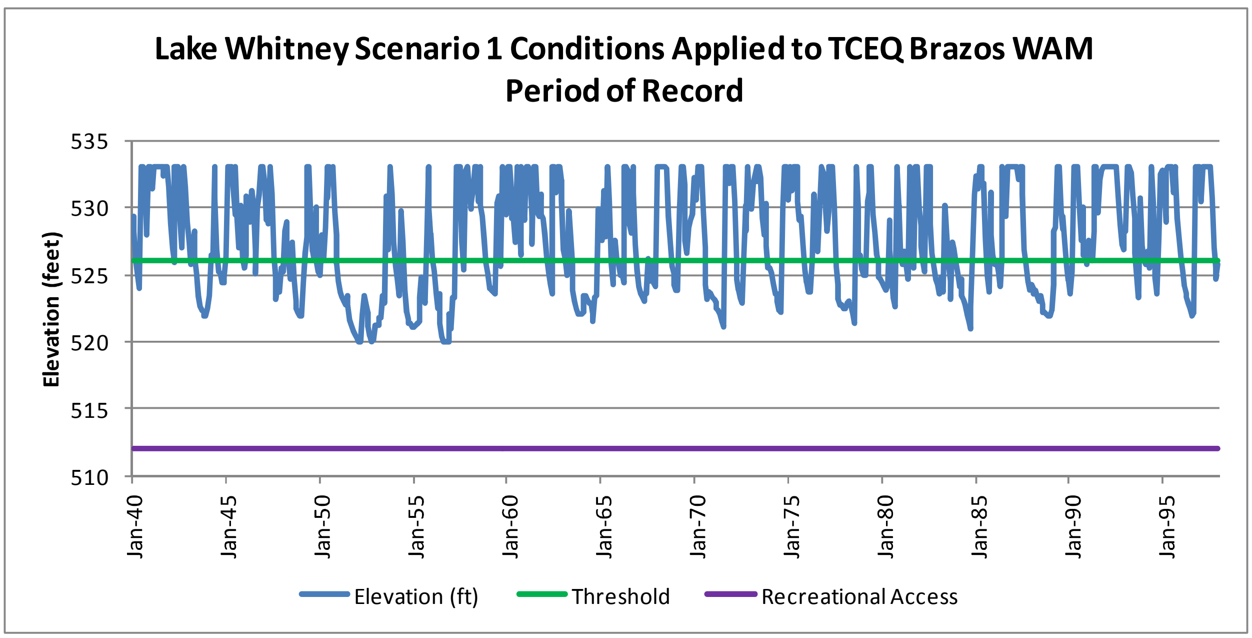

Lake Stillhouse Hollow Scenario 2, 2025 Conditions
Elevation Frequency
Elevation (feet)
625
620
615
610
605
600
595
590
585
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access Impeded

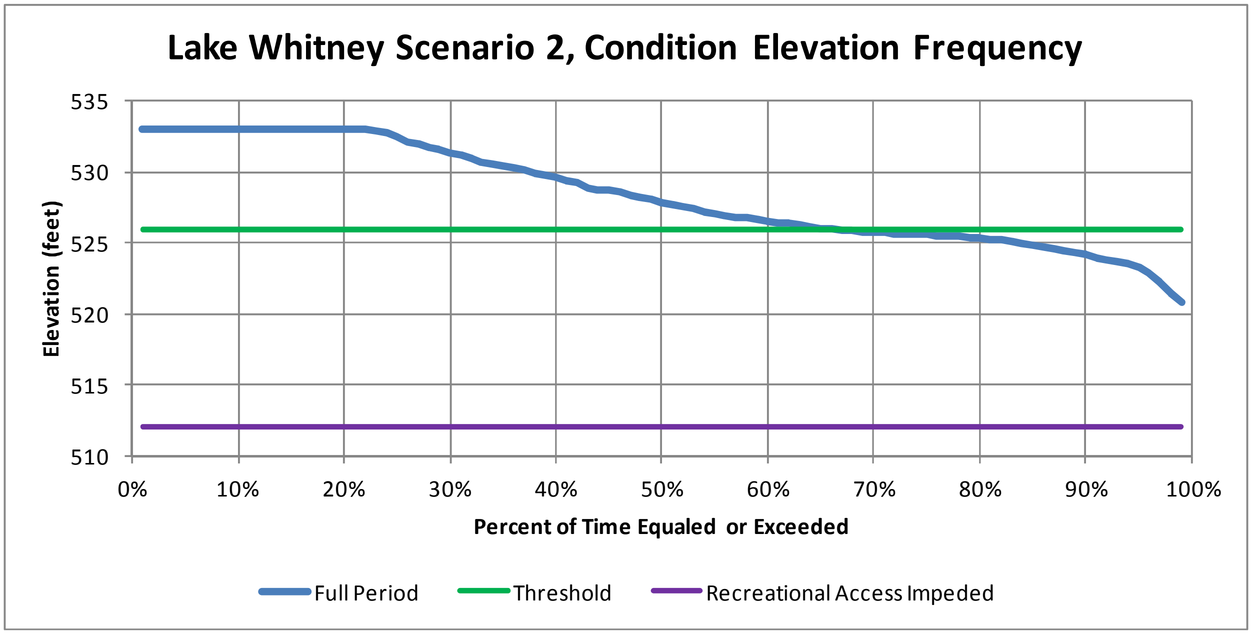

Lake Stillhouse Hollow Scenario 2 Conditions Applied to
TCEQ Brazos WAM Period of Record
Elevation (feet)
625
620
615
610
605
600
595
590
585
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Elevation (ft)
Threshold
Recreational Access Impeded

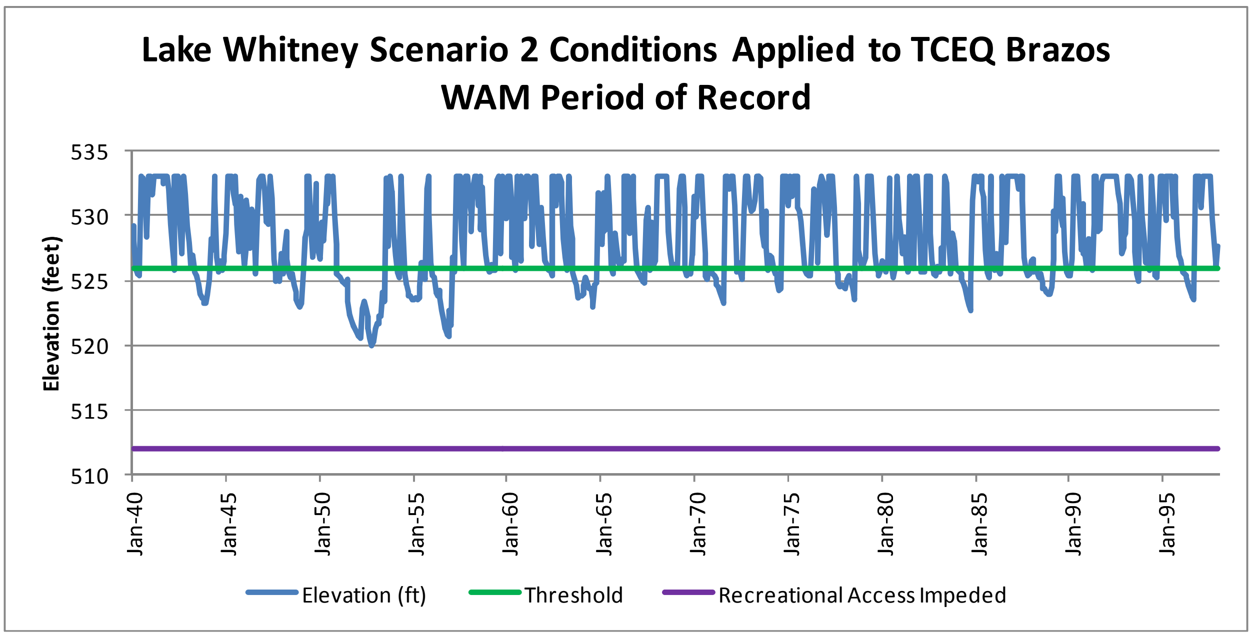

Lake Stillhouse Hollow Scenario 3, 2025 Conditions
Elevation Frequency
Elevation (feet)
625
620
615
610
605
600
595
590
585
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access Impeded

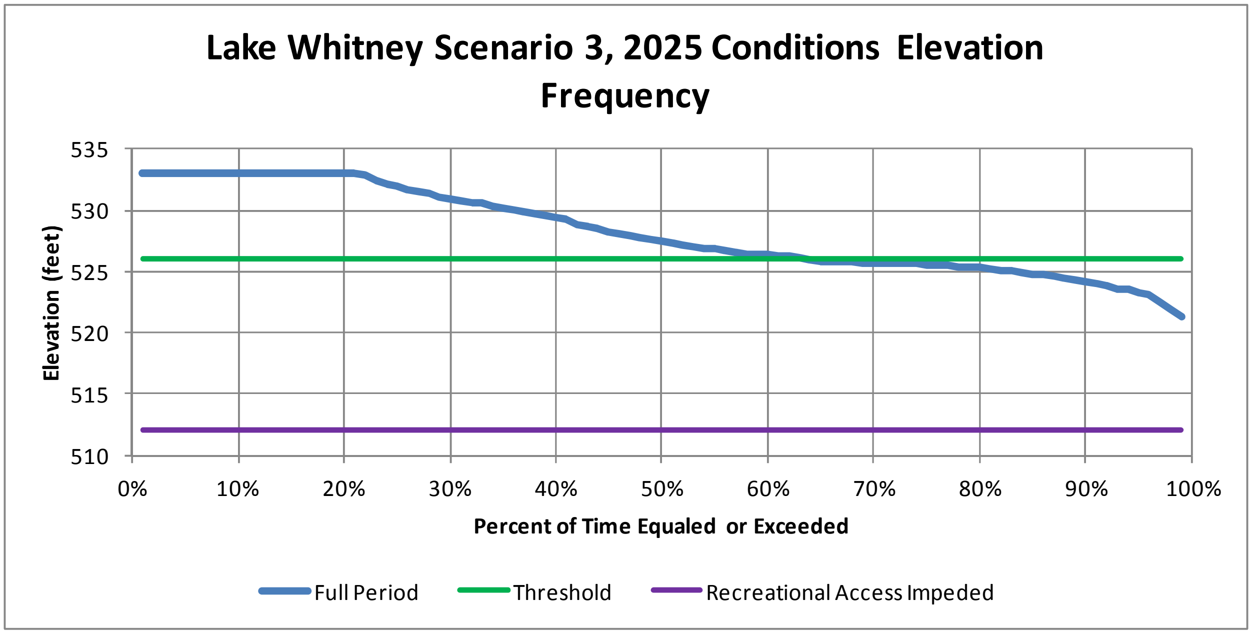

Lake Stillhouse Hollow Scenario 3 Conditions Applied to
TCEQ Brazos WAM Period of Record
Elevation (feet)
625
620
615
610
605
600
595
590
585
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Elevation (ft)
Threshold
Recreational Access Impeded


Lake Whitney Scenario 1, Current Conditions Frequency
535
530
525
520
515
510
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access

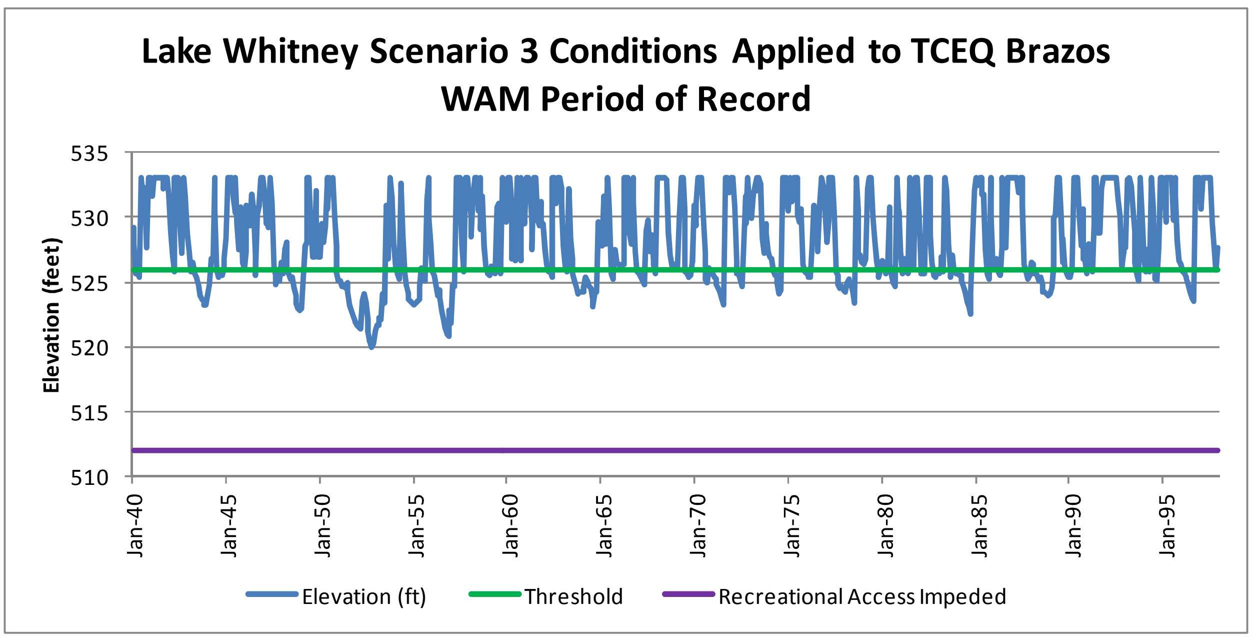

Lake Whitney Scenario 1 Conditions Applied to TCEQ Brazos WAM Period of Record
535
530
525
520
515
510
Elevation (feet)
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Elevation (ft)
Threshold
Recreational Access


Lake Whitney Scenario 2, Condition Elevation Frequency
535
530
525
520
515
510
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access Impeded


Lake Whitney Scenario 2 Conditions Applied to TCEQ Brazos WAM Period of Record
535
530
525
520
515
510
Elevation (feet)
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Elevation (ft)
Threshold
Recreational Access Impeded



Lake Whitney Scenario 3, 2025 Conditions Elevation Frequency
535
530
525
520
515
510
Elevation (feet)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Full Period
Threshold
Recreational Access Impeded

Lake Whitney Scenario 3 Conditions Applied to TCEQ Brazos WAM Period of Record
535
530
525
520
515
510
Elevation (feet)
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Elevation (ft)
Threshold
Recreational Access Impeded